SCIENTIFIC AMERICAN

No. SUPPLEMENT 248

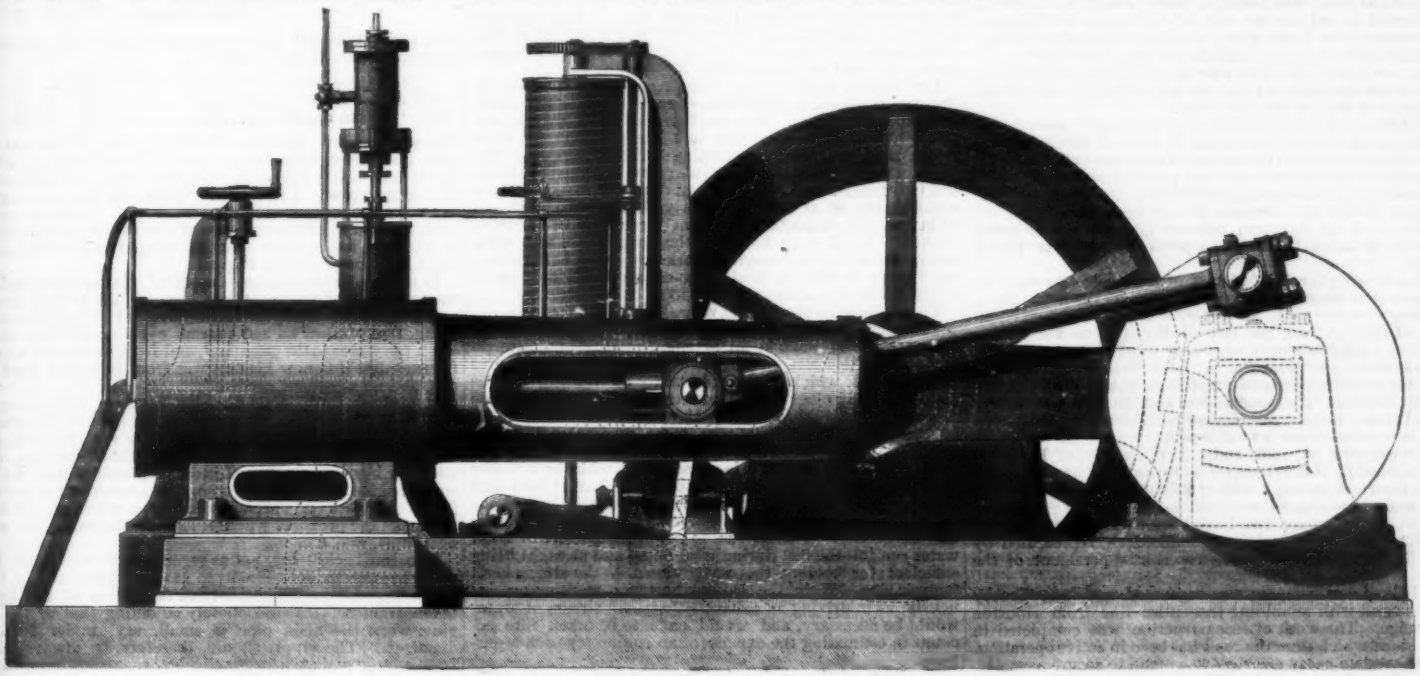
Scientific American Supplement, Vol. X., No. 248
Scientific American, established 1845.

NEW YORK, OCTOBER 2, 1880.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

IMPROVED HORIZONTAL STEAM ENGINE.

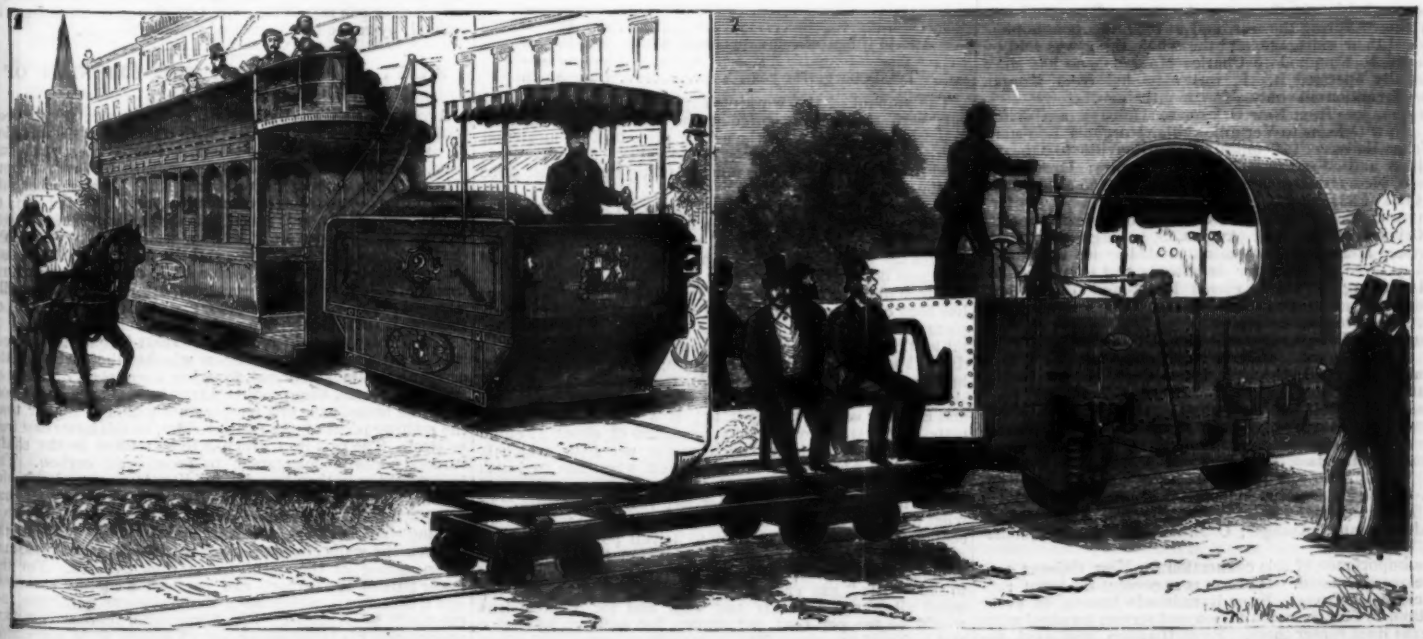
THE arrangement is, in some respects, a departure from general practice, the design is well considered, and the workmanship is good. The engines have been made for the Australian Agricultural Company for underground haulage of coal wagons along an incline 3,000 yards in length, the winding drums, which are of wrought iron, 6 ft. in diameter and 3 ft. wide between the cheeks, being capable of holding 3,000 yards of 1 in. Craddock's steel wire rope which it is intended to employ, and of exerting a maximum tractive force of 10 tons. The steam cylinders, which are steam jacketed and fitted with steam relief valves, are 20 in. in diameter, and the stroke is 40 in. The large spur wheel, which is cast in two parts, is 7 ft. 7¾ in. in diameter, and 13½ in. wide, the pinion being 2 ft. 6½ in. diameter and 14 in. wide. The guide and crosshead wearing surfaces are very large, the guide surfaces being bored out at the same setting as that required for facing the end to which the cylinder is fixed. The crosshead slippers are adjustable for wear, though the surfaces are so large that wear sufficient to demand adjustment will not, under ordinary circumstances, take place for years. Oil troughs are cast on the pillars carrying the main bearings, so that the oil from the bearings cannot run to waste, and these castings, as well as all the others of the engines, are remarkably good and clean. As the engine has to be lowered into the pit by means of the ordinary pit winding gear, it had to be constructed so that no part weighed more than 2 tons, and hence the construction of the winding drums of wrought iron. The bedplate is made in six parts, bolted together with faced joints. A wrought iron platform is erected between the cylinders, and on this are collected the wheels and levers for controlling the speed and direction of revolution of the engines. The engines are reversed by means of a steam cylinder and oil cataract cylinder superposed, and steam being admitted above or below this steam cylinder, the engine is reversed with the greatest ease, and yet without dangerous or injurious suddenness, and the link can be maintained in any position by closing the cock on the pipe communicating between the two ends of the oil cataract cylinder. The connection between the reversing cylinder and the link motions will be gathered from the elevation and plan. An indicator is attached, consisting of a drum marked with a spiral line and fitted with a pointer, which follows the spiral by means of a screw which raises and lowers it, and thus indicates, on a scale of 1 in. to the fathom, the position of the truck train on the incline. The engines were constructed under an outline specification of Mr. John Fowler, London, by Messrs. Tangye Bros., of Birmingham.—*The Engineer.*



IMPROVED HORIZONTAL STEAM ENGINE.

THE BEAUMONT COMPRESSED AIR LOCOMOTIVE.

THIS engine, which is the invention of Colonel Beaumont, of the Royal Engineers, and which has now been running for some months in the Royal Arsenal at Woolwich, is intended for use upon tramways, underground railways, or any line of rails where smoke, steam, and noise are objectionable. The principle is also applicable to pleasure launches and ferry-boats on rivers where short intermittent runs only are required. The motive power, compressed air, is supplied by a stationary engine, and is stored in the reservoir of the locomotive at a pressure of 1,000 pounds to the square inch. From this reservoir it passes successively through three cylinders, when its force being expended it is ejected into the atmosphere. The difficulties usually resulting from the extreme cold caused by the expansion of highly compressed air are overcome by means of a diminutive steam generator, which warms the air as it issues from the exhaust ports. Among the numerous advantages claimed for the invention are the following: it can be made light or heavy



1.—LOCOMOTIVE FOR TRAMWAYS. 2.—TRIAL OF THE EXPERIMENTAL ENGINE AT WOOLWICH ARSENAL.

THE BEAUMONT COMPRESSED AIR ENGINE.

in proportion to the work required of it; it can be run at any speed attained by ordinary locomotives, and is under perfect control, only one man being required to drive it; one charge of air enables it to run a distance of fifteen to twenty miles; fresh charging from the stationary compressor can be effected as quickly as the changing of horses, and finally the cost of working is less than steam-power and much less than horse-power. The trials at Woolwich have been perfectly satisfactory in every way, and there is every probability that the patent will ere long be brought into very general use, a limited company having already been started for working it, the temporary office being at 3 Victoria Street, Westminster, S. W.—*London Graphic.*

THE NEW ORLEANS AND TEXAS RAILROAD.

After years of "hope deferred," with all the uncertainties and vicissitudes attendant upon so unsatisfactory a state of things, New Orleans has at length reached a triumph in her commercial prospects—possibly the greatest in her commercial history.

At 5:15 A.M. on Sunday, the 29th of August, 1880, the first through passenger train—a special for the conveyance of those most interested in the consummation of the enterprise—left the Algiers depot, New Orleans, for Houston, Texas, without change. The first train from Houston, with a distinguished party of railroad men on board, arrived the evening before.

It is about unnecessary to state that New Orleans was almost in a fever of excitement over the event, and well she might be; for by the completion of this road the Crescent City becomes the center and shipping port for all the commerce of the great Southwest, a trade which has hitherto been forced to find exit by way of St. Louis or Chicago. The exports from Texas alone, which are annually increasing in an indefinite ratio, exceeds in value fifty millions of dollars, very little of which ever found its way to New Orleans; while the future of imports for the Empire State must be largely by way of the new route.

The history of the enterprise is a checkered one; for in addition to the general depression in railroad affairs all over the country, the New Orleans and Texas has suffered, with all Southern enterprises, from the political situation. And independently of the special good which the completion of this road affords New Orleans, it is a promising omen for the future of the Southern railroad interests which needs the spur of successful effort to point the way to future growth.

The following is a brief history of the road: As early as 1854 an act of incorporation passed the Texas legislature, granting a charter to A. M. Gentry *et al.*, to build and equip a line of railway from the city of Houston to the Sabine River, at a point where Orange now stands. In 1855 a survey was made, and thereafter a road was built. But the road was poorly constructed, and from many other causes rapidly declined. The bondholders and the civil war nearly blotted it out, and the military authorities taking possession of it, it became almost a total wreck.

On September 1st, 1869, Judge J. F. Crosby, of Houston, took possession of it as receiver under an order of the United States Court, it having a debt of $3,000,000 over it. In 1870 some temporary repairs were effected, and during that year and the one following, two forced sales were made, when it was purchased by the original bondholders, represented by John T. Terry, of New York, who is now president of the road.

In 1874, a new company was organized, and Judge Crosby was charged with rebuilding the entire line from Houston to Orange. The work of reconstruction was completed in 1876, since which time the road has been in active operation. After that date every exertion was made to secure a connection to New Orleans, which at last, in October, 1878, resulted in a contract entered into between President Charles A. Whitney, representing the Morgan Company, and President J. J. McComb, of the Louisiana Western, and the building of the line from Orange to Vermilionville, giving an all-rail route from Houston to New Orleans. The Louisiana Western, or the Gap, as it has been called, is a successor to the old New Orleans, Mobile, and Texas line. Three years ago, Col. Thomas Adams, of Philadelphia, succeeded in interesting capital in its behalf. Work on it was begun in 1878, and the last spike driven August 26, 1880. The road has been substantially and well built.

The other factor in the system is the Morgan Road. In 1851, a charter was granted, and the New Orleans, Opelousas and Great Western Railroad was incorporated to run from New Orleans to Opelousas, La., expecting to connect with a line to Texas. The road was constructed and in running order to Morgan City in 1857. To build this 80 miles a bonded indebtedness was incurred. The road was nearly ruined during the war, and in 1869 the bondholders foreclosed their mortgage, and the whole thing was sold by the sheriff to Commodore Charles Morgan, who has since successfully operated it. It was extended from Morgan City to Vermilionville only a few months ago.

The distances from New Orleans to Houston are as follows: New Orleans to Vermilionville, Morgan's Louisiana and Texas Railway, 144 miles; Vermilionville to Orange, Louisiana and Western Railway, 112 miles; Orange to Houston, New Orleans and Texas Railway, 105 miles, making a total of 361 miles.

The first train from Houston reached Algiers, opposite New Orleans, at 7:40 P.M., August 28, having made the run in fourteen hours and thirty minutes deducting two hours and fifty-three minutes for detentions and stoppages, the actual running time was eleven hours and thirty-seven minutes—splendid time for a new road. The following railroad officials were on the train:

Houston and Texas Central—Gen. G. Jordan, vice-president; A. H. Swanson, general superintendent; J. Waldo, general freight and passenger agent; Capt. Haynes, geologist, and W. B. Botts, attorney. Houston East and West Texas—Paul Bremond, president. Central and Montgomery—F. A. Rice, president. Texas and New Orleans—Judge J. F. Crosby, vice-president; C. A. Burton, superintendent; W. H. Masters, freight and passenger agent, and P. B. Watson, auditor. Texas Transportation Company—Chas. Evershade, superintendent. Texas Express Company—C. T. Campbell, superintendent. Louisiana Western—Theodore Adams, manager; C. R. Adams, assistant manager.

The importance of this connection for New Orleans cannot be overestimated. Houston is at present the great railroad center of Texas. From it railroads branch in every direction, in fact, between fifteen and sixteen hundred miles of Texas lines center there. From Houston, westward, the Texas Central runs to Austin; then there is the Houston and San Antonio Railroad, which will form, with the New Orleans and Texas, a complete link of 575 miles due west, with a fair prospect of the line being continued to El Paso, to join the California Southern Pacific. So that the possibilities of an increased commerce of large proportions may be safely anticipated by New Orleans. That she does anticipate such a possibility is evinced by the movements already suggested for increasing her present facilities. To the cattle trade of Texas she at once has an eye, and the question of stock yards is presented. Altogether, there are signs of an enlarging spirit in business circles, and prospects of an era of push in the Crescent City to which the completion of the New Orleans and Texas will materially contribute.—*Railway Review.*

COST OF WORKING A GAS ENGINE.*

ON THE COST OF WORKING A GAS ENGINE, COMPARED WITH THE SAME WORK DONE BY STEAM POWER.

By Mr. F. T. Linton, Leith Gas Works.

It may perhaps be as well to explain that, in the remarks which I have the honor to lay before you, I do not propose going into any description of the principles of construction of the various gas engines now in the market. I have no doubt that the members are conversant with these already, from the various communications of late years on the subject, and especially the very able paper read last year by Mr. Carr, of Halifax, before the British Association of Gas Managers.

My desire is simply to put before you what my experience has been on a gas engine which was erected at the works of the Edinburgh and Leith Gas Company in the spring of last year; and, as I suppose that my brother managers, like myself, are being frequently applied to for information and advice as to these engines, I thought that, if I put together a few notes as to the cost of working our gas engine, with a comparison of the cost of doing the same work by steam power, it might be of some little service.

The engine is an "Otto" silent gas engine, made by Crossley Brothers, of Manchester, and is of three and a half nominal horse-power. It is employed to drive various machines in our workshops, such as a Roots blower for three smiths' fires, a large screw-cutting lathe, a screwing machine, a drilling machine, a circular saw, two smaller lathes, and two grindstones. The amount of power required varies considerably, as, at one time, nearly all these machines may be in use, and, at another time, not more than two or three of them. In all cases, however, the smoothness and regularity with which the engine works are very noticeable—there being no sensible diminution or acceleration of speed as the different machines are put in or out of action.

The attendance required is very slight.

The engine can be started in a minute's time, and the lubricating being done by an ingenious self-acting arrangement, no further attention is needed till the engine requires to be stopped, which is done instantly by shutting off the gas. The only other labor needed is to examine the slide valves once a week, to see that the passages to the cylinder are clear; and this does not take more than from fifteen to twenty minutes.

There is a water cistern in connection with the cylinder jacket for keeping the cylinder cool, but I have found that the amount of water required after the first filling of the cistern is practically *nil*, as the temperature of the water has never risen so much as to require a stream of fresh water run in—the rest during meal hours and at night being sufficient for cooling the water down to the atmospheric temperature. Were the engine, however, working continuously, as in driving an exhauster, a small stream of water would be necessary, and would have to be taken into account in estimating the expense of an engine for such a purpose.

The cost of the engine for the year from May 15, 1879, to May 15, 1880, working fifty-seven hours per week, was:

	£	s.	d.
Gas for engine and side lights, 99,000 cubic feet, at 4s. 2d. per 1,000 ft..	20	12	6
Sixteen gallons of sperm oil for lubrication, at 3s. 6d. per gallon....	2	16	0
Attendance estimated at one hour per day, at 4d. per hour	5	4	0
Making total of working expenses,	28	12	6

The first cost of engine and cistern complete was £170, and the annual tear and wear may be taken at the rate of 7½ per cent.:

	£	s.	d.
Equal to.....	11	18	0
Depreciation, the same.....	11	18	0
Making together.....	23	16	0
Add to this working expenses as above,	28	12	6
Total charge for year.....	52	8	6

The amount of the working expenses would necessarily vary with the varying price of gas in different localities. What is given above was the selling price in Edinburgh and Leith last year, but, of course, the actual expense, where it is used in a gas works, will be not the selling but the cost price of the gas.

With regard to the percentages charged for tear and wear and depreciation, these are, I am sure, ample, looking to the well-finished and substantial style in which these engines are got up, the absence of complicated working parts, and the large bearing surfaces of the parts liable to be worn out.

The amount of power derived from the above expenditure has been on the average at least two horse power. As explained before, the use of several of the machines is intermittent, but it takes about one and a half horse power to drive those that are constantly in use; and the addition of a half horse power to the average for those that are used occasionally (including as they do a circular saw of large size and a heavy screw-cutting lathe), is a very moderate estimate. This works out to an expenditure of about 17 cubic feet of gas per indicated horse power per hour, which is much below what is stated to be used when the engine is worked with a full load, and seems to bear out what was stated by Mr. Carr in his paper last year, that, contrary to what might be expected at first sight, the engine works more economically when not used up to its full power.

The cost of a steam engine and boiler of three and a half nominal horse power, and equal in respect of workmanship to the "Otto" gas engine, would be about £110; and the usual allowance for tear and wear and for depreciation would be ten per cent. per annum for each, on an engine and boiler of this size. This, relatively to seven and a half for the gas engine, is not at all excessive, as, of course, the boiler involves more wear and tear and depreciation:

The working expenses would be:

	£	s.	d.
For fuel at 8s. per week for fifty-two weeks.....	20	16	0
Wages of attendant at 12s. per week,	31	4	0
Oil for lubrication (same as gas engine).....	2	16	0
Water supply for boiler.....	2	10	0
Making total working expenses...	57	6	0
Add for wear and tear 10 per cent. on cost....	11	0	0
Add for depreciation 10 per cent. on cost....	11	0	0
Making total charges for year.....	79	6	0

It will be borne in mind that the cost of fuel will be more or less than what is given above, according to locality; but it is a fair estimate, checked by actual experience of the working of a small steam engine and boiler in our works, and by comparison of what it cost various users of similar engines in the neighborhood. The wages of an attendant I have taken at 18s. per week, and I have allowed 6s. off that, on the supposition (which in many cases, however, could not be realized) that the man could devote so much of his time to other work.

The general results, then, are as follow:

	£	s.	d.
Working expenses of gas engine....	28	12	6
" " steam engine..	57	6	0

and, taking tear and wear and depreciation into account, the total annual charge would be,

	£	s.	d.
For gas engine.....	52	8	6
" steam engine.....	79	6	0

The advantage is, therefore, largely in favor of the gas engine, and I venture to think that if I have erred at all in the comparison it is in under, not over estimating the cost of the steam engine. I have also to point out that our engine is constantly going during working hours. There are, however, an infinite number of cases where power is needed only at intervals, and in such cases the comparison would be still more in favor of the gas engine.

In all cases where we have supplied gas for these engines the testimony of the users has been highly in their favor; and not long ago one gentleman gave me his experience as being, that "when he had a steam engine it cost him 18s. a week for wages to the attendant, and from 10s. to 12s. a week for fuel; but that now his cost was from 4s. to 5s. a week for gas, and no attendant needed."

In addition to the saving in cost, however, the gas engine has other advantages: It occupies small space; is always ready at a moment's notice; does away with the risk and danger of explosion, thereby reducing cost of insurance, and allowing insurance to be effected in places where, with a steam engine and boiler, the companies would not undertake it. It also needs no special building or chimney, and does not make the premises where it is used uncomfortable with heat, dust, and cinders.

One drawback it has, not as regards those who use it, but as giving trouble occasionally to gas managers, namely, that the action of the engine causes an oscillation of the lights taken from service immediately adjoining that of the engine, when the main pipe is small, say, under 4 in. in diameter. The supply should, therefore, be always taken from a large main where practicable, or, at any rate, where the main is less than 4 in. in diameter, no other service should be taken in close proximity to that for the engine. I had lately a correspondence with Messrs. Crossley about this, and they promised to send me a governor which is used on the Continent for preventing this oscillation, but it has not yet come to hand. I may also note that the pressure of gas in the main must be at least equal to that of seven-tenths of an inch of water.

That gas engines will, ere long, come into extensive use, I think certain, not only as supplementers to some extent of steam engines, but also as affording a cheap and efficient motive power in a great number of places where the use of steam is difficult or impossible. It is obviously the interest of gas companies and gas managers to forward their employment as much as possible, because they not only increase consumption of gas, but, by using it chiefly during the hours of daylight, no corresponding increase of capital expenditure is involved; and their extensive use would not only benefit gas manufacturers, but also gas consumers in general, by reducing the cost of making the gas.

* Paper read before North British Association of Gas Managers—Perth Meeting.

SHAFT FURNACE FOR THE REFINING OF CAST IRON.

According to M. Krupp, when a mixture of pig iron with basic oxides of iron, and with or without the addition of oxides of manganese and lime, is treated in a shaft-furnace, which is furnished with a garniture of ores of iron, "bauxite," manganese, bituminous shale, or any other substance in which carbon predominates, or which is basic; or if the above mentioned mixture is treated in a shaft-furnace consisting of a reservoir of double walls, between which a current of cold air circulates, and the melting-pot or breast-pan of which is furnished with a basic or neuter garniture, then the cast iron loses its greatest part of manganese, silicon, sulphur, and phosphorus, and, besides this, a part of the ores is reduced and the yield is augmented.

When this system of refining in a shaft-furnace is adopted, it is of little importance to know whether the carbon of the cast iron is attacked or not, for when a sufficient quantity of coke is present, the product arrives in the melting-pot, or in the breast-pan, at a temperature which is higher than the melting point of the final product, be this latter cast iron or steel. The cast iron which is to be refined in the shaft-furnace needs no manganese to preserve its carbon. The iron would only then lose its fluidity, if a remarkable decarburation took place in the melting-pot or in the breast-pan.

It is better, with this system, to use a furnace with a cooling shaft, without garniture in the melting chamber, because the walls cover themselves with a layer of ores, and all repairing of the garniture is thus avoided. For the lower part of the furnace can be used a cooling reservoir and a breast-pan, which has a carboniferous garniture and can easily be replaced. Fig. 3, opposite, represents a furnace of this kind, the upper part of which, A, is suspended from the feeding platform, B; the air penetrates and circulates around the shaft by means of a slide, *a*. The molten metal flows out through the opening, *b*, which occurs at the

midst of the cooling reservoir, F, into the movable breast-pan, B¹: this latter is fastened against the stove and made air-tight by means of a light layer of convenient matters.

To render the refining more complete, it is well to place the melting zone of the stove as high as possible by means of a series of bellows pipes, which are placed at a certain height, in such a manner that the load of the stove is already molten above the principal pipes, whilst one or several ranges more of pipes, lower down, serve to reheat the molten metal. But if a furnace of limited height is to be employed, one consisting of several stories can be advantageously used, which is so constructed that the shaft of the lower story serves as a breast-pan for the upper shaft. The iron and the ores may both descend at the same time from the upper story to the lower story (the way through which the molten masses have to pass is thus simply prolonged), or the metal may be separated from the scoria by means of an outlet. Fig. 4 shows a furnace of this construction. The molten metal falls from the upper story, A, into the lower story, B, by means of the outlet, D, while the scoria flows out through the opening, *a*. In the second shaft, the melting continues after an addition of new ores and coke. The purified metal falls at *d*, through the outlet, E, into the movable breast-pan, C, while the scoria flows out through the opening, *c*. The two shafts are furnished with a higher range of principal bellows pipes and with a lower range of supplementary ones.

This double refining easily permits the phosphorus which is contained in the mass to be brought down from 1·6 per cent. to 0·1 per cent., because in each of the shafts about 75 per cent. of the phosphorus is carried away.

Fig. 3.

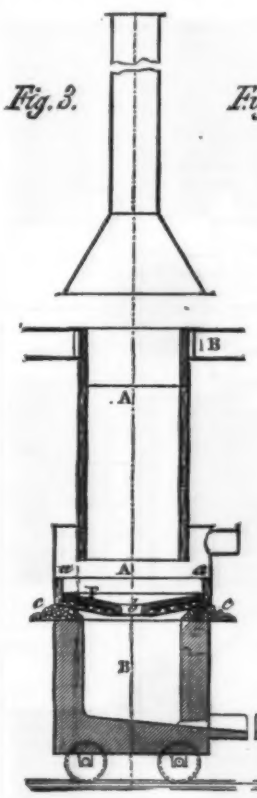
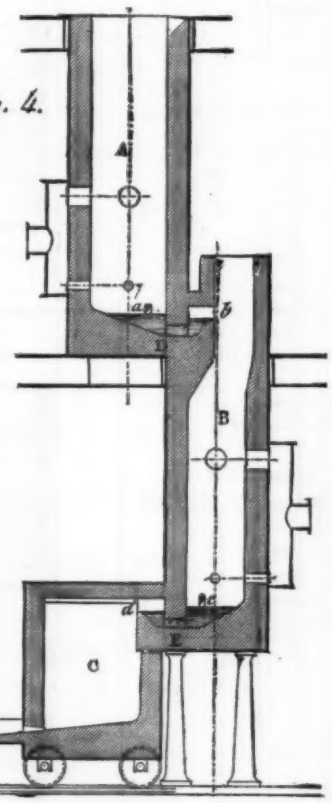


Fig. 4.



SHAFT FURNACE FOR THE REFINING OF CAST IRON.

A series of assays, which were made with the same iron in a small experimenting furnace, has given the following results:

	Raw Iron.	I.	II.	III.	IV.	V.
Carbon	3·73	3·43	3·48	3·00	3·40	3·40
Silica	0·47	0·002	0·002	0·004	0·005	0·002
Manganese	3·56	0·45	0·35	0 128	0·210	0·470
Copper	0·25	....	....	.....	.....	.....
Phosphorus	0·60	0·273	0·20	0·136	0·187	0·210

The ore for refining contained:

Ferric oxide	98·20
Manganous oxide	0·10
Phosphoric acid	0·54
Lime	0·10
Water	1·10
	100·04

The fusion of the first 600 kilogrammes (1,322·47 lb. avoirdupois) was not a very great success; the metal still contained, at its tapping, as analysis I. shows, 0·273 per cent. of phosphorus; the second tapping had already given a better result, but only the assay III. can be considered as normal—the mass was fluid, and separated itself completely from the scoria. In assays IV. and V., the way which the molten mass had to pass was again shorter, and the yield of phosphorus was greater. Those slags which were the richest in phosphorus, and which were obtained by the above-mentioned process, had the following composition:

Silica	17·60
Ferrous oxide	41·28
Manganous oxide	26·30
Alumina	7·25
Lime	1·46
Manganese	0·36
Phosphoric acid	5·28
Sulphur	0·60
	100·19

The addition of lime permits the use of a much smaller quantity of ores, because, in this case, the silica combines with the lime and not with the ores.

According to M. Krupp, this refining process can also be used with a high furnace. The molten iron is made to run from the high furnace into an elevated cupola, filled with ores and coke or bricks of ore, or it is made to flow into a shaft which is placed upon a cupola, and from there into the latter through an opening which is as small as possible.

This method is not only suited to permit a further treatment of the metal in the Siemens-Martin furnace, or in the purifier connected with the Bessemer apparatus, or by other similar processes, but it is also especially well adapted for the puddling. The purified cast iron can, if necessary, be transferred from the cupola, in a liquid state, to the puddling furnace, whose bottom will not be attacked, as this usually happens, when a molten mass, which is almost free from manganese and silica, is poured into it.

ON THE VARYING CONDITION OF CARBON IN STEEL, AND ITS INFLUENCE ON EGGERTZ'S COLORATION PROCESS.

By J. SPEAR PARKER, F.I.C.

THE ease and rapidity with which results can be obtained by means of Eggertz's coloration process for the estimation of carbon, have rendered its adoption almost universal in the laboratories of steel works. I believe, however, that most chemists using the process have occasionally noticed anomalous results, which have aroused suspicions as to its reliability, and some I know have used it while regarding the results obtained as only roughly approximate. For my own part, exercising minute care in every stage, I used it for many years in the belief that its results could be fully depended upon; and although my suspicions had been once or twice excited, I was not at all prepared for the very serious variations to which after a thorough investigation I discovered it was liable. The standard I at that time habitually employed was of crucible steel, and agreed in its color indications with others in use in several large works in this country, and with one or two test bars from Sweden with which I had compared it. But I first became convinced that something must be seriously wrong with the process on the receipt from my friend, Mr. A. H. Allen, of drillings from a sample of hard Bessemer steel in which he had carefully estimated the carbon by combustion, and which gave, when compared with my crucible steel standard coloration, results fully one-sixth too low.

After a number of experiments with different samples of crucible and Bessemer steel of various tempers, by carefully observing the phenomena when the cold nitric acid was added to the steel drillings, and by numerous check estimations by combustion or chromic acid oxidation, I became convinced that carbon was capable of existing in steel in different conditions, and that steel containing the same percentage of carbon might give, when dissolved in nitric acid, a greater or less degree of coloration, according as the carbon was in one condition or another. Fortunately also I was able to apply a method of correction, which, although entailing additional trouble, rendered the process in all ordinary cases susceptible of a high degree of accuracy.

In most samples of Bessemer steel containing over 0·60 per cent. of carbon taken from the ingot, the carbon exists in a form agreeing with the sample received from Mr. Allen, already alluded to; while, on the other hand, most samples of crucible steel contain it in a form which gives a higher coloration for the same amount of carbon—nearly in the ratio of six to five. If to a decigramme of each of two such steels containing a similar percentage of carbon, an equal amount of nitric acid be added, the difference of appearance as they dissolve side by side is most striking. In the first case the color of the liquid while the first rapid action is proceeding appears of an orange-*yellow*; in the second a dark Vandyke-*brown*, sometimes approaching black; and when the effervescence has subsided, the appearance of the residue, as yet undissolved, is equally distinctive—consisting in the first case almost entirely of small skeletons, retaining the shape of the fragments of steel from which they are derived, while, in the second, it is entirely of a light flocculent character, and very much darker in color than the former. For the sake of simplicity I shall call the first the "yellow," the second the "brown" form of carbon. Were there only these two extremes there would be no difficulty about the matter; but any grade intermediate between the two may occur, and in rare cases even greater differences are noticeable. The following are examples of the difference in coloration results obtained in a few typical samples:

By coloration	0·88	By chromic acid	0·873
" "	0·73	" "	0·733
" "	0·61	" "	0·615
" "	0·605	" "	0·595

In the above the carbon appeared in the "yellow" form, as was the case with the standard used throughout; but in the following samples it was in the "brown" form.

By coloration	1·26 (1·05)	By chromic acid,	1·059
" "	0·95 (0·79)	" "	0·773
" "	0·875(0·73)	" "	0·695

The figures in parentheses are obtained by deducting one-sixth from the figures given by color test, and it will be noticed that in the last case an even greater deduction is required to obtain the true amount of carbon; so again, in a few cases a slight addition is necessary to the result obtained from the standard here employed, which does not represent quite the extreme limit of "yellowness." Taking the two most extreme points I have hitherto met with in actual practice (the steel being unworked, hammered, or rolled, but *not* hardened), the ratio of color obtained from the same amount of carbon would be nearly as three to four; but with very rare exceptions the variation does not exceed the limit of five to six.

By very careful observation of the indications when dissolving, followed by numerous check tests by gravimetric analysis, I was able to work out a scale of fractional additions and subtractions, by the application of which I was enabled to obtain results of a high degree of accuracy. This system I have employed during nearly two and a half years with most satisfactory results, and only when a high percentage of carbon is indicated from which a large deduction has to be made do I feel any hesitation in fully relying upon the exactness of the estimation thus obtained. It is impossible, of course, by mere description to enable other workers to apply such a scale; each observer must work one out for himself. This will require time and trouble, and its application considerably complicates the coloration process, but such a system is absolutely necessary if reliable results are required.

The carbon from the same piece of steel may be readily changed from the one modification to the other. If, for instance, an ingot of hard Bessemer steel, with its carbon in the "yellow" condition, be strongly heated and allowed to cool slowly, it will generally be more or less completely converted into the "brown" form; by the uncorrected coloration method it would appear to contain a higher percentage of carbon than before; but apply combustion and its amount will be found to be unaltered (except, of course, near the surface, where it may be sensibly diminished owing to superficial oxidation in the heating). On the other hand, a steel containing carbon in the "brown" form, if hardened, even though subsequently annealed so as to admit of drilling, will probably have it converted into the "yellow;" judging by the uncorrected coloration results the percentage of carbon would appear to have diminished, although the same amount is still actually present.

As steel when hardened cannot be filed or drilled, no method occurred to me for a long time by which I could test quantitatively the effect upon the coloration results of the change in condition of carbon which takes place on hardening. The following device, however, enabled me to obtain satisfactory results. Drillings of steel, not too large to be subsequently dissolved in nitric acid for the coloration test, were closely packed in the fine powder from the same sample, and tightly wrapped up in platinum foil. The whole was then heated to a bright red and plunged into cold water. Although where air had penetrated the usual dark blue temper color was shown, a large portion of the sample was so effectually protected from even superficial oxidation as to retain its original color and luster. The sample was immediately pressed between blotting paper, and thoroughly dried in the water bath. Fragments were then carefully picked out which retained their metallic luster and natural color (or at most a faint straw), and a decigramme was dissolved in nitric acid in the usual way. The first sample operated upon contained its carbon nearly in the brown condition, and the result of hardening was to convert it into the extreme yellow form.

By coloration—
Unhardened steel.. 1
Hardened " .. 0·815 } Actual carbon... 0·86

But when I operated in a similar manner upon steel containing its carbon already in the "yellow" condition, I found that the coloration results after hardening were still nearly one-fifth lower (*e. g.*, 0·74 and 0·60 respectively), the carbon being evidently further modified in the same direction In this case the color of the solution, after action of cold nitric acid, appeared of a peculiar deep orange color, while, instead of the very decided skeletons left undissolved in the unhardened sample, nearly the whole went into solution before heating, the very minute residue consisting of a few diminutive orange filaments. It is fortunately impossible to drill hardened steel, so that in practice one has not to contend against this further distinction; steel which is to be tested by the coloration process should never be hardened, as even if subsequently annealed I consider the results so obtained untrustworthy.

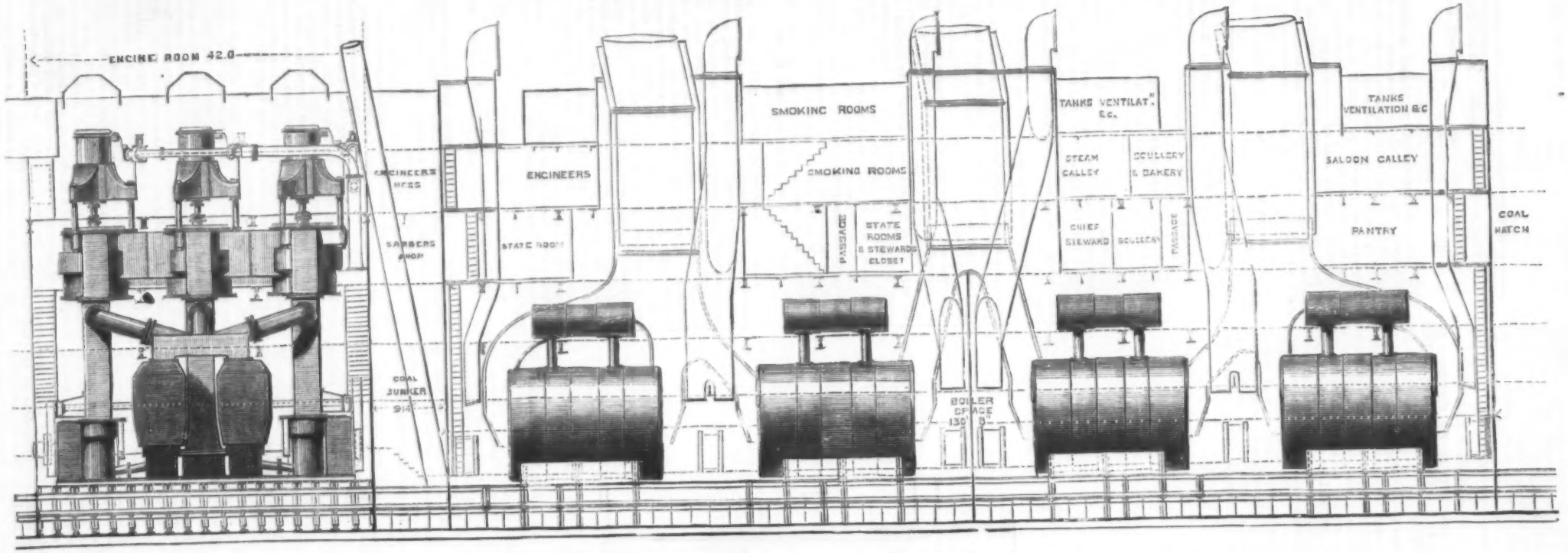
The action of nitric acid upon steel, although the most conclusive, is not the only proof that there is a real difference in condition of the carbon in various samples. Many observers had previously noticed that hydrochloric acid acts in a different manner upon steel in the hardened and unhardened state,* their results being well summarized by Prof. Akerman (*Journal of the Iron and Steel Institute*, 1879, pp. 504–6), who remarks: "It thus appears that the carbon commonly called combined ought properly to be divided into two kinds, viz., first, the carbon most intimately combined with the iron, which we, in accordance with Rinman's proposal, shall call *hardening carbon*, inasmuch as it characterizes the well hardened steel; and, further, the carbon incompletely combined with the iron, which may be said to be in a sort of passage to graphite, and which Rinman called *cement carbon*, because it occurs in largest proportion in the undrawn blister or cement steel."

I have found, moreover, that when the steels have been treated with cupric salts (as a preliminary to combustion),

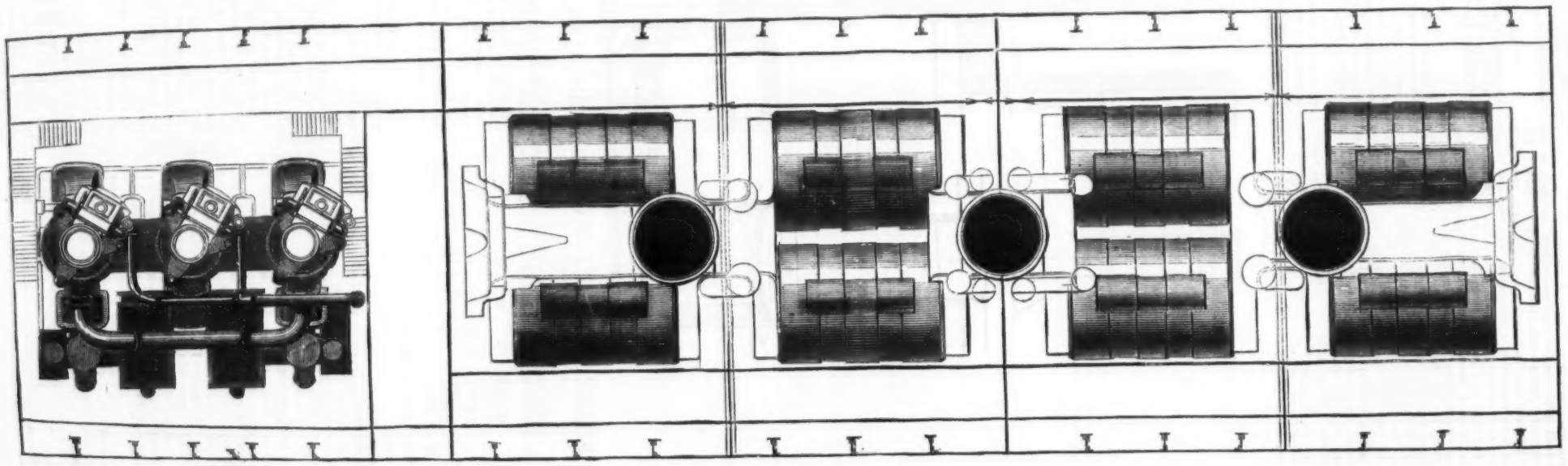
* I may take this opportunity of remarking that the statement so frequently reproduced that unhardened steel contains *graphite* which passes into the combined state on hardening is quite erroneous I have never observed true graphite in the enormous numbers of hard steels which have passed through my hands, and I have made special search for it by treating large quantities of highly carbureted crucible steel with hydrochloric acid, but always with negative results.

GENERAL ARRANGEMENT OF ENGINES AND BOILERS OF S. S. CITY OF ROME.

THE BARROW SHIPBUILDING COMPANY, BARROW-IN-FURNESS, ENGINEERS.



GENERAL ARRANGEMENT OF MACHINERY IN ELEVATION AND PLAN



the residue of carbon, etc., left undissolved presents a totally different appearance, according as the carbon existed in the "brown" or "yellow" form. In the former case it remains as a powder in an extremely fine state of division, with a great tendency to penetrate through the asbestos filter when washed; in the latter it is much more bulky, and apparently consists of porous carbonaceous skeletons of the original drillings of steel.

What is the exact nature of the difference in condition of the carbon which gives rise to these various phenomena? It is because I have as yet been unable satisfactorily to solve this problem that I have so long delayed publication of my observations. The carbon in white cast iron and steel is usually spoken of as "combined." Mr. Snelus considers that it rather exists in a state of solution. Now, experiments made by MM. Troost and Hautefeuille showed that a pure white carbureted cast iron gave a greater amount of heat when treated with mercuric chloride in the calorimeter than pure iron itself; hence the absorption of the carbon by the iron had been accompanied by absorption of heat, and its condition was physically analogous to a state of solution. But a carbide of iron and manganese, on the other hand, gave very much less evolution of heat with mercuric chloride, and indicated the existence of a true *compound* of carbon and metal.

Is it not then possible that in what I have called the brown form the carbon is in a state physically analogous to solution, whereas in the yellow form it is really chemically combined with the iron? This appears to me the most probable explanation. As yet, however, it is only conjectural; but I intend shortly to examine microscopically the etched polished surfaces of a series of specimens I have been collecting containing the carbon in extreme forms, a method of investigation which I hope may enable me to solve the problem, or at any rate throw considerable light upon the subject. I thought it right, however, without further delay to draw the attention of chemists to a source of variation in the coloration process, which, if not duly corrected, most seriously affects its accuracy, a source of error which so far as I can ascertain has hitherto escaped detection.—*Chemical News.*

STEAM DREDGING FOR OYSTERS.

GEO. M. GRAVES, of Oyster Point, New Haven, has now in process of construction for the brothers Jeremiah and George H. Smith, of Long Wharf, an oyster boat designed for steam dredging. She is 71 feet long, 17 feet beam, and 6 feet deep; her engine 30 horse power, and her screw propeller 53 inches. The boiler is on board, and the work is being pushed as rapidly as possible. There is an over deck, from seven to nine feet high, made water-tight. In the sides of this over deck, in a line with the main hatchway, are openings, six by eight feet, which when dredging open inwardly and are hooked to the ceiling. Through these openings the dredging is done by steam, saving the weary "back breaking" that attends dredging in the ordinary sailboat. Forward is the forecastle, in which are berths or bunks for the crew. Directly over this is the pilot house, and back of this the captain's quarters. The expense of running this steam is, for fuel, not over $1 per day, six men at $15 to $20 per month for each. She will dredge in a day from 700 to 1,000 bushels, taking at each lift 12 or 15 bushels, while the sailing boat at each lift will not get more than a bushel or two at once, and during the day will be doing extremely well if she gathers 40 or 50 bushels.—*Sea World.*

THE STEAMSHIP CITY OF ROME.

AT the recent meeting of the Institution of Mechanical Engineers, Barrow-in-Furness, Mr. Humphreys read an interesting paper descriptive of the great steamship for the Inman line which is now to be seen in course of construction on the stocks of the Barrow Shipbuilding Company. After glancing at the progress of steam shipping, Mr. Humphreys went on to say that with a view of still further providing for the comfort and swift transport of the rapidly increasing numbers who cross the Atlantic between New York and Liverpool, the Inman Steamship Company decided some little time since to order a vessel which should combine the highest rate of speed with the maximum of comfort and luxury. To fulfill these conditions it was deemed necessary that the vessel should be of very much greater dimensions than any ship then belonging to the company; and after the most careful deliberation it was considered advisable to go to a size of at least 8,000 tons.

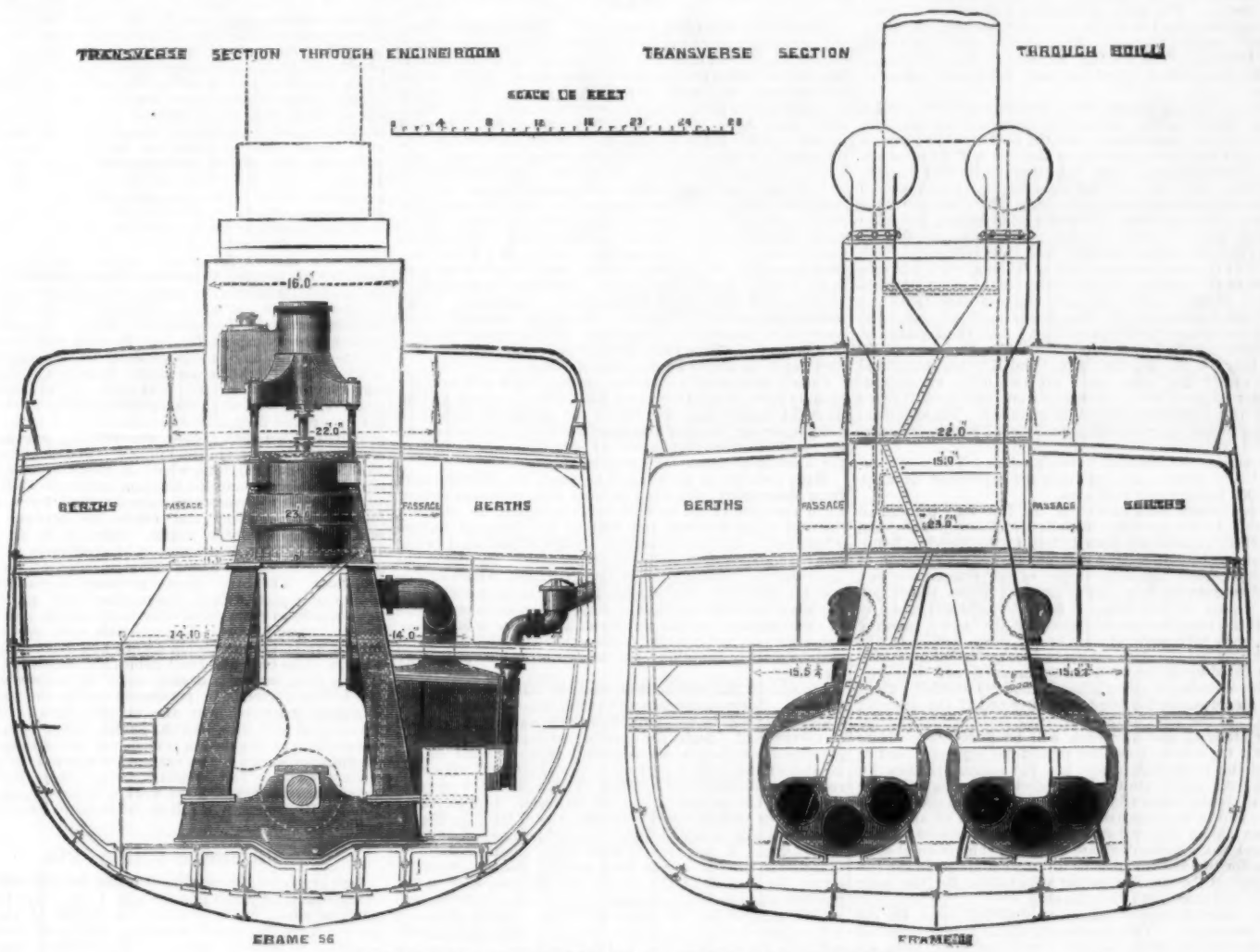
The dimensions finally adopted were, length between perpendiculars, 546 ft.; length over all, 600 ft.; extreme breadth, 52 ft. 3 in.; depth of hold, 37 ft. The great length as compared with the breadth insured long easy lines for the high speed required; and the depth of hold being only 37 ft., as compared with the beam of 52 ft., insured great stability and consequent comfort for the passengers. The general features were indicated by drawings. The distinctive type of the Inman line has not been departed from in respect of the perhaps old fashioned but still handsome profile, with clipper bow, figure head, and bowsprit. The vessel is to be rigged with four masts; and here again the handsome full ship rig of the Inman line has been adhered to, with the addition of the fore-and-aft rigged jigger mast, rendered necessary by the enormous length of the vessel. She will have three funnels, each painted with the company's white band.

A point calling for special notice is the large number of separate compartments formed by water-tight bulkheads, each extending to the main deck. The largest of these compartments are only about 60 ft. long; and supposing that from collision or other cause one of these was filled with water, the trim of the vessel would not be materially affected. With a view of giving still further safety in the event of a collision or stranding, the boilers are arranged in two boiler rooms, entirely separated from each other by means of a water-tight iron bulkhead. This reduces what in nearly all full-powered steamships is a vast single compartment into two of moderate size, 60 ft. in length; and in the event of either boiler room being flooded, it still leaves the vessel with half her boiler power available, giving a speed of 13 to 14 knots per hour. There is also the usual water-tight bulkhead separating the engine room from the after boiler room.

Another feature of great importance is the disposition of the boilers. They are eight in number, of the double-ended form, and arranged fore and aft in four blocks of two, with the transverse bulkhead already mentioned between the central blocks. This arrangement provides for the bulk of the coal being carried in the sides of the vessel; and advantage is taken to make the bunkers form part of the structure. They extend in a straight line the entire length of the space occupied by the engines and boilers, and being in the same line with the outer side keelsons, they are incorporated with them, forming two strong longitudinal girders. These add considerably to the strength of the ship in the most important part, where in many vessels there is rather a loss than an accession of strength. It is intended further to make these bunkers and keelsons water-tight, and so form an inner skin, which will afford admirable protection to the boilers and machinery in case of the vessel being cut into amidships—an accident that in ordinary vessels almost invariably causes instant foundering. These bunkers, and all the bulkheads, are fitted with proper water-tight doors, which will be of the type adopted by the Admiralty. These will be worked both from the main deck and from below, and will be fitted with tell-tales on deck, to show clearly whether they are open or closed.

At the fore end a double bottom has been arranged in Nos. 1 and 2 cargo holds, for a distance of 150 ft. from the stem. This will add greatly to the safety of the ship in the event of her stranding on a rock or suffering a bow-on collision, as the bow is thereby greatly strengthened, and the risk of water getting into the vessel reduced. The sizes of the forward compartments generally are also small compared with the general dimensions. Constant care has thus been taken in working out the arrangements to provide as far as possible against the dangers of collision or other accident.

The stern frame or post, now making at the Mersey Steel and Iron Works, will be the largest single forging ever made for such a purpose; the finished weight is estimated to be not less than 33 tons. The framing of the vessel is of the ordinary type, the floors being 34 in. deep at the center line. The frames are in one length from center line to gunwale, and are of angle irons 7 in. by 4 in., and 60 ft. in length. The reverse frames are also in one length of 4 in. by 4 in. angle iron. The butts of the frames, reverse frames, and floors are all carefully shifted from one another. The whole of the beams are of the Butterley bulb sections, each rolled in one length.



ENGINES OF THE S. S. CITY OF ROME.

The vessel has two complete iron decks above, while the lower deck is complete for half the length, and has wide plating on each side for the remainder. She has nine tiers of keelsons, all running right fore and aft; the five central ones are of uniform height, so as to be carried unbroken through the engine and boiler seatings. The shell plating is arranged on a principle that has been applied with great success to all the large transatlantic steamers which have been built in Barrow. The inside plates form a complete skin, fitted accurately edge to edge and butt to butt, with covering plates, half of the width of the inside strakes, fitted outside. By this arrangement the shearing strains on the riveting are greatly diminished; and the plating in the way of the outside covering strakes being doubled, thinner plates are used than with the ordinary mode of plating as per Lloyd's rules, and so much sounder and closer work is insured. The hold stanchions are arranged in two tiers, one on each side, the better to support and strengthen the long beams. The whole of the deck houses, turtle decks, and other erections on the upper deck are of iron, to stand the strains of an Atlantic winter.

The question of propelling this great vessel at so high a speed as it is anticipated will be obtained—namely 18 knots per hour—was one that demanded long and very careful consideration. It was ultimately decided that it would be better to adhere to the single screw arrangement, and to adopt a propeller 24 ft. in diameter, driven by three sets inverted "tandem" engines, working on three cranks disposed at an angle of 120° with one another. The "tandem" engine, as is well known, has the high pressure cylinder placed in a line behind or above the low pressure cylinder. This arrangement was adopted in preference to other types

of three-crank engines, in which the powers developed are not so uniform, in order that absolutely equal efforts might be given out by each of the three engines, thus insuring a perfectly balanced and evenly working machine; it is expected that when these engines are nicely adjusted they will work almost without noise. Each high pressure cylinder is carried upon three wrought iron columns, thus giving plenty of light and easy access to the stuffing boxes; and also enabling the cylinder covers, which are made in halves, to be readily withdrawn, should it be desired to examine or repair the cylinders or pistons. The slide valves are driven by an independent shaft, worked by two pairs of mortise wheels, one at each end of the engines—an arrangement which has the advantage of requiring comparatively small eccentrics. Moreover, as the valve faces are disposed toward the front of the engines, this arrangement makes them very accessible.

The crank shaft is to be a built shaft, and, together with the screw shafting, is being made by Sir Joseph Whitworth & Co. of their fluid compressed steel. The shafting is made hollow. Each length is made from a hollow cylindrical ingot, which, while in the molten state, is subjected to a heavy hydraulic pressure. The ingot is afterwards reheated and placed on a mandrel, and is then forged and drawn by hydraulic pressure, until it ultimately assumes the form of a double collared shaft. There are three high pressure cylinders 43 in. diameter, and three low pressure cylinders 86 in. diameter, all 6 ft. stroke. The diameter of the crank shaft is 25 in., and of the crank pins 26 in. The length of the main bearings is 33½ in., and of the crank pins 28 in. The crank shaft, as built up complete, will weigh 64 tons; had it been made of iron and solid the weight would have been 73 tons. The propeller shafting is 24 in. diameter, and the hole through it 14 in. diameter. The thrust shaft has thirteen collars, 39½ in. diameter, giving a surface of 6,000 square inches. This piece of shafting will weigh 17 tons. The propeller shaft is 25 in. diameter and 30½ ft. long, and will weigh 18 tons. The engine bed plate will weigh 100 tons. The cooling surface of the condensers is 17,000 square feet, equal to nearly seventeen miles of tubing.

There are two air pumps, 39 in. diameter and 3 ft. stroke; and two double acting circulating pumps, 26 in. diameter and 3 ft. stroke; these pumps and the feed and bilge pumps are worked by levers attached to the aft and forward engines. There is also a large centrifugal pumping engine, which can either be used for pumping heavy leaks or can also discharge through the condenser. There are also three auxiliary pumping engines for feeding the boilers, for bilge pumping, and for deck purposes. Steam is supplied by eight cylindrical tubular boilers, fired from both ends. Each boiler is 14 ft. mean diameter and 19 ft. long, with a steam receiver 13 ft. long and 4 ft. diameter; and has six furnaces 3 ft. 9 in. diameter, three at each end; so that there are forty-eight furnaces in all. The fire bars are 6 ft. long, giving a grate surface 1,080 square feet. The shell plates of the boilers, supplied by Sir John Brown & Co., are 24 ft. 8 in. long, 4 ft. 4½ in. wide, and 1¼ in. thick, and weigh nearly 2½ tons each; all the holes are drilled. The internal parts are of Bowling iron; and each furnace has its own separate combustion chamber. These boilers are constructed for a working pressure of 90 lb. per square inch.

The engines are intended to work constantly at 8,000 indicated horse power, although they are capable of developing 10,000 horse power indicated.

The promenade deck carries at the fore end the saloon skylight. In the hurricane deck house, the captain's, and chief officer's cabins are placed close to the steering house and look-out bridge, so that they are always near in case of necessity. Abaft this is the upper saloon companion, and abaft this again the large upper smoking room, which is a novel feature in this ship; it being thought advisable, in view of the large number of passengers, to fit two smoking rooms, each with separate stair to the cabin deck. In the after deckhouse is a deck saloon or lounge for ladies, which will be fitted up in the most elegant manner, and will prevent the necessity of going below in showery weather. Abaft this is a companion leading to the after end of the sleeping cabins. At the sides of this hurricane deck will be carried twelve lifeboats, one of which will be fitted as a steam launch. On this deck are also placed the capstans, and at each of the cargo hatchways are the steam winches for working the cargo. On the upper deck, commencing at the fore end, is the steam windlass for working the anchors and cables; and in the compartments on each side of the bow, accommodation is provided for the crew and firemen. At the after end of the turtle deck are all the washhouses and other fittings for the accommodation of the emigrants in the forward part of the vessel, together with cabins for the petty officers, and stores, etc., for the ship.

Next comes the upper saloon, or drawing room, for the use of passengers. This apartment, which will be fitted up very handsomely with lounges round the sides, is in the form of a wide gallery with a large rectangular opening into the dining saloon below, thus giving great height and light to the latter apartment. Above this opening is a large skylight, richly ornamented; at the fore end will be a grand piano, and at the after end the grand staircase leading to the dining room below.

Proceeding aft we come to the galleys, sculleries, bakery, and other offices, all of which will be fitted with the best cooking ranges, etc. Next is the lower smoking room, which will be fitted similarly to the upper; the paneling of these rooms will probably be in wainscot oak, the floors laid in mosaic pavement, and the upholstery in morocco leather. Abaft this are the rooms for the officers and engineers, which, being exceptionally large and lofty, will be unusually comfortable. Under the after turtle deck is the accommodation for hospitals, lavatories, and other offices for emigrants, who are berthed in the after 'tween decks.

At the extreme after end is the wheel house, where will be placed the steam steering gear, with a very strong hand steering gear, to be used in case of the steam gear breaking down. The steam gear will be controlled by means of shafting from the bridge; from which there will be also a telegraphic communication, should it be desired to steer the vessel from aft. A large quadrant of wrought iron is attached to the rudder stock, and is provided with deep grooves in which the steering chains work. On the main deck, commencing at the fore end, are two compartments for the accommodation of about 260 emigrants. A special feature in this vessel is that the berths are arranged in single instead of double tiers, each tier being separated from the next by a passage with large side light at the end. This adds greatly to the ventilation, light, and comfort of the passengers. The height in the 'tween decks is 9 ft.

Next comes the grand dining saloon, 72 ft. long, 52 ft. wide, and 9 ft. high, or 17 ft. in the way of the large opening through the drawing room above. On each side of the vessel, from the saloon to the after end of the engine room, are placed state rooms providing for 271 passengers. These rooms are arranged in two blocks on each side, an inner and an outer; the outer rooms are 6 ft. 6 in. by 7 ft. 6 in., and the inner rooms 6 ft. 6 in. by 5 ft. 9 in., both 9 ft. high. In the outer rooms the lower berth is made to slide in or out, while the berth above is arranged on the Pullman car principle, so that it can be folded up out of the way when required—an arrangement which will be much more comfortable than the usual ship's sleeping berth. The inner rooms are fitted with the ordinary bed places, and light will be furnished from a 14 in. side scuttle. Amidships are placed retiring rooms, baths and lavatories, barber's shops, etc.

Abaft the cabin bulkhead the main deck is fitted for about 240 emigrants, in the same manner as for those forward; accommodation is therefore provided on the main deck for 500 emigrants in all. Accommodation can also be provided on the lower deck for 1,000 emigrants more, making a grand total of 1,500. In way of the engine and boiler casings will be fitted up the mail room, the specie room, and the passengers' luggage room, all opening off the main deck; and along the sides of the engine room will be berths for the saloon stewards, etc.

In concluding the description of this great steamer it may be stated that her estimated weight, complete and ready for sea, is 8,000 tons, and that her displacement, at 26 ft. mean draught, is 13,500 tons, so that she will have a dead weight carrying power of 5,500 tons. The cubical contents of her holds will give her a measurement capacity of 7,720 tons, at 50 cubic feet to the ton. She is expected to be ready for work in the course of next summer.—*The Engineer.*

STAIRS.

When were stairs first thought of? Who can tell? They were evidently preceded by the ladder; but, strange to say, the only ladder—a figurative one—mentioned in the Bible is that which held so prominent a place in Jacob's dream, when he journeyed to Haran in search of a wife. How many youthful minds have wondered over that story; how many little ones have pored—literally pawed—over the print in the family Bible of the angel hosts, ascending and descending without in any way disturbing the sleeper who had so hard a pillow! How bright the angel faces seemed to us in those early days, and how we longed to peer through the misty veil that hid the topmost round in heaven. The first mention of stairs in the Bible is in the account of Solomon's Temple, where winding stairs (which shows an advanced stage of stair-building) are spoken of. Later they were frequently brought into notice, and are last mentioned in the time of the apostles, when "Paul stood on the stairs" in Jerusalem, and told of his marvelous conversion. Paul's history will never be forgotten, but on the stairs of which he stood we know little or nothing. Will not some one give us a history of stairs, from Solomon's Temple down to our own day? It would be very entertaining.

Does it ever occur to one that the stairs by which he daily mounts to the several stories of his dwelling, are not all that he could desire? that the rise is too rapid, the treads too narrow, or that the space set apart for them is too contracted for comfort and convenience? If not, he is easily suited, or the stairs in his house are exceptionably good.

Many persons, in building, take pains to hide the stairs from observation; this must be from some mistaken notion. I can conceive of an unwillingness to expose an ordinary flight of stairs to view; but that an architectural feature which can be made so attractive should be neglected or hid away from sight is to me incomprehensible. The Swiss put their stairs on the exterior of their cottages, which in this way are made very picturesque, for they come in well with the broad eves, low roofs, and wide galleries on every side of the structure, but the privacy of the house is in a measure destroyed, and in a climate like our own, subject to great extremes, there is nothing in such an arrangement that we can adopt.

I have said that stairs can be made an attractive feature in a house. Every architect knows this; but no man can build a flight that will be comfortable, or even safe, in a cramped or narrow hall. Stairs are exacting in their demands, and if these demands are not complied with we shall be reminded of the neglect every time we use them. We may resort to make-shifts (if inclined to do so) in other parts of the house, but we cannot put off the stairs with anything and say "it will do," and no coaxing will bring an ill-contrived or badly arranged flight of stairs into use on any possible terms. A good run is what every flight of stairs requires. If the run is not long enough, then we must increase the height of the risers; and the rise, after it has reached a certain point, becomes trying when difficult, and at last dangerous. In many houses, in almost all cheap houses, the rise is eight inches. Even the back stairs should not have a more rapid rise, and for the principal stairs this is wholly inadmissible. The other extreme, a fault not often committed, is to have the rise too low. Anything below six inches is almost as trying as the other extreme, but it is not so dangerous. The most satisfactory rise is six and a half inches, and from that, if crowded, we may go on to seven inches without drawing attention to the tread; but above that point the rise begins to fatigue us. A rise of six and a half inches requires a tread of at least fourteen inches, and for one of nine inches a tread of eight inches will suffice. But I cannot believe that any one would put a rise of that height into any dwelling. One might as well resort to a ladder, and indeed, a rise of this kind would be but little better than such a contrivance to reach the chamber floor. Whether the risers are high or low, they must all be of a uniform height. Any departure from this rule is always attended with mischievous results. If all the risers in a flight are seven inches, with one exception, and that one is either six or eight inches high, every person who passes up or down will trip at that stair. No matter how often he goes up or down, he will always trip at that point.

Stairs, to be effective, should be wide between the wall and rail, with one or two flats or landings; and in no instance should they be disfigured by the introduction of winders. The rail must be heavy, the balusters something more than "dipper handles," and at the foot let there be a newel, on which the architect may display his taste and skill. It need not be elaborate, but it is a conspicuous object, and it should have something more to recommend it to our notice than the cheap and stereotyped forms, which may be bought at the turner's by the hundred.

It is pleasant to mount up stairs properly planned, especially if they are well-lighted and ventilated. And if on the first landing the architect can contrive a bay, deeply recessed and provided with seats beneath the wide windows, he will, by so doing, add another charm to the house. Here those who are advanced in years, and who find it difficult to climb the whole flight at a time, may rest awhile, or sit and chat. Here the little ones love to pause in their passage up and down, and here flowers, growing in a *jardiniere* in front of the window, may send their fragrance through the house.—*Champlin, in American Architect.*

ARTISTS' HOMES.—No. 6.

MR. J. C. DOLLMAN'S HOUSE, CHISWICK.

The examples which we have thus far illustrated of "Artists' Homes" have all been more or less of an extensive character. Although our primary intention, in giving this series of artists' residences and studios, was to illustrate those chiefly of our leading painters, sculptors, and architects, yet we had no idea of alone confining our drawings to houses strictly of this class. Such buildings must, of course, possess an interest peculiarly their own—often, indeed, from the celebrity of their owners, rather than from the architectural merit of the particular house illustrated. The houses, however, which will always have a more general value to the major number of our readers, will necessarily be those of a less costly plan, and thus well within the reach of most of that large class included under the title of artists. Of this more limited character of building is the house, with studio, for Mr. J. C. Dollman, which we illustrate on opposite page. The building is simply one of a pair built in Newton Grove, Bedford Park, Chiswick, on the old orchard site; and, as an example of architecture, may be taken to be as unpretending and as inexpensive as it can possibly be, depending entirely upon the commonsense convenience of its interior arrangements and picturesque proportions of its elevation for all the effect which has been aimed at. The almost universal requirements of economy and limited area of site were in this case a very primary consideration, and for this reason two houses were determined upon, in order that the most might be made of both the individual plots on which the houses stand, by placing the buildings together in the center of the combined areas, instead of each house in the middle of either, while another important stipulation was to preserve as many of the standing and thickly-placed trees as possible. The studio here, as in all painters' houses, governs the planning of the house; and, to avoid the foliage on every side, as well as for questions of economy, this apartment has been arranged on the first floor, and is reached from a roomy proportioned hall by an easy and wide staircase, immediately approached from the entrance door, so that visitors need not necessarily be brought into the more strictly private part of the house. A models' stair is arranged in the rear, with shelves for plants beyond, and a glass house over, for the purpose of painting with open-air effects from the model. A balcony is arranged over the diningroom bay for the painter's use, when requiring a brief release from the confinement of the studio, and another is arranged with a south-western aspect, for use in chill and early spring weather. The large gable window, which constitutes the chief means of lighting the studio, directly faces the north, and for top-light effects, a skylight is contrived, with shutters to be used when such a flood of light is not required. On the ground floor, a dining room, 20 ft. 6 in. by 15 ft., is provided with a garden door, conveniently arranged, and a serving hatchway from the kitchen. The drawing room is 18 ft. long and 13 ft. 6 in. wide. A good storeroom is placed next the staircase, and the kitchen, which is 17 ft. 6 in. by 12 ft. 6 in., is well screened from the hall by a curtained lobby. The scullery and offices are beyond. On the first floor, besides the studio, which is 26 ft. 6 in. by 19 ft., two large bedrooms, with bathroom and w. c., are arranged, similar rooms being repeated on the next, or top, floor. The other house possesses a south-west and south-east aspect, with a commodious hall and staircase, large reception rooms, and convenient arrangements on the first and second floors. The materials used are red bricks for the walls, with cut brick arches and sills, pilasters, and strings. The cove and front gables are finished in plaster of gray lime, having a drying color of creamy white and Mr. Dollman intends to personally enrich the gables with scratched ornament, after the manner shown. The roofs are covered with tiles, like the gables, and a feature in the composition of the design is made of the arrangement of the chimney stacks. The external woodwork is painted a creamy white. The architect, from whose designs and under whose supervision the work is being executed, is Mr. Maurice B. Adams, A.R.I.B.A., of Bedford Park, Chiswick.—*Building News.*

SIR JOSEPH WHITWORTH.

The greatest of Roman poets began his epic with the announcement: "Arms and the man I sing;" and Carlyle has said that when, in like manner, the glories of the present age are made the subject of a great epic it will be more appropriate to begin by saying: "Tools and the man I sing." If ever that idea is realized, surely the man whose name will be most distinguished in connection with the tools of the nineteenth century will be Sir Joseph Whitworth. No man has done more to promote efficiency and facility in the use of workshop appliances; and in addition to providing, with princely liberality, for the improvement of technical education, and inventing a whole set of machine tools that have revolutionized the labors of our workshops, he has also risen to the rank of an inventor in the manufacture of steel of high class quality.

Joseph Whitworth was born at Stockport, in 1803, and at the age of 14 was placed under the care of his uncle, a millowner, in Derbyshire, where he acquired an elementary knowledge of machinery. At the age of 18 he left the mill and entered the workshop. In the capacity of a mechanic he worked for three or four years in Manchester, and then went to London, where for eight years he worked at Maudsley & Clements, the former of whom was himself an inventor of tools, and the latter was associated with Babbage in the construction of his calculating machine. By this laborious training, and in this school of inventors, Joseph Whitworth acquired that practical knowledge and mechanical skill which, aided by his fertile powers of invention, afterwards yielded such abundant results. In those days the working mechanic was almost unaided by machinery; the planing machine was then unknown, the chisel and hammer, the file, the primitive lathe, and a simple screw-cutting machine formed the whole repertory of engineers' tools. The measure then in use was a two-foot rule divided into eighths of an inch; and though the skilled workmen ventured to go to 16ths, 32ds, bare 32ds, and full 32ds, the general results were of a rude and primitive kind, and work of a high character could only be produced by superior skill on the part of the workmen. It was in these circumstances that young Whitworth early saw the great need

Artist's Homes No. 6

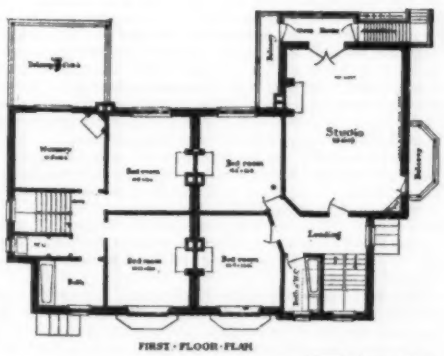
Mr J. C. DOLLMAN'S HOUSE

Newton Grove · Chiswick ·

Bedford Park

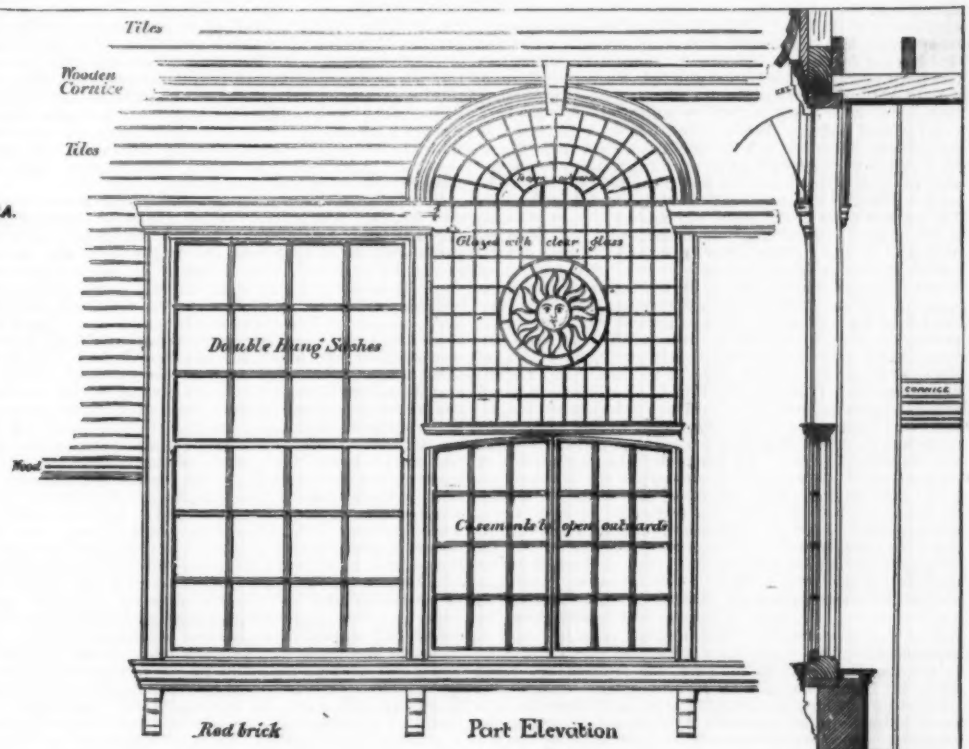
Maurice B. Adams A.R.I.B.A.

· Architect ·



FIRST · FLOOR · PLAN

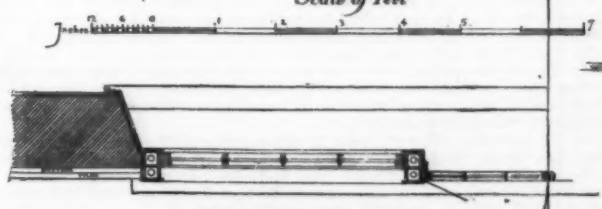
GROUND PLAN
Scale of feet



Part Elevation

Detail of Studio Large Window

Scale of Feet



Part plan of window

Sash-bar

Section

there was for improved tools and machinery. In the cotton spinning and weaving factories around Manchester there was a growing demand for mechanical work of a higher character to cheapen and improve the complicated machinery which was then in use, but which it was difficult to make.

Whitworth's early connection with the cotton trade impressed him with the great advantages to be gained by improvements in the means of producing more perfect and exact machinery. Among the many skilled workmen employed in Maudsley & Clements' workshop he was esteemed the best; but his inventive genius was as great as his manual skill; and not content, therefore, with personal distinction as a mechanic, he set himself to the production of machine tools—machines made for the purpose of producing other machinery. To this work he devoted his years from attaining manhood to middle life; and before he was 30 years of age he succeeded in producing plane surfaces with a degree of precision which was then unknown, and which formed the groundwork of nearly all his other machines. This achievement was perfected and described by him in 1840, and was followed by his improvements in the use of the slide and the construction of his machines for measuring the ten-thousandth and millionth part of an inch. The old method of producing true planes was that of grinding the surfaces of plates alternately with emery powder and water, which was as imperfect as it was laborious. Whitworth endeavored with much labor and ingenuity to produce true planes by means of the steel straight-edge and scraper, and having succeeded in 1830 in "originating" the first true planes ever made, the work of producing copies of them sufficiently accurate for workshop purposes became comparatively easy, and one of the best and most successful machines for this work is his edge planing machine, which can be made of almost any size. Sir Joseph has one in his own works capable of taking a single cut 40 feet in length, the bed of which is 50 feet long, and its grooves are considered the longest true planes that have ever been made. So exactly can surface plates be made by his apparatus that if one of them be placed upon another, when clean and dry, the upper one will appear to float upon the lower one without being actually in contact with it, the weight of the upper plate being insufficient to expel, except by slow degrees, the thin film of air between their surfaces; but if the air is expelled, the plates will adhere together, so that by lifting the upper one the lower will be lifted along with it as if they formed one plate. The economy of this invention is not less than its mechanical precision, as the previous cost of planing surfaces, then done by hand, was 12s a foot; and now with this machine it is only a penny a foot.

It was while working as a journeyman mechanic that Whitworth conceived the idea of making true planes; and having partly accomplished this task he returned from London to Manchester in 1833, and began business on his own account. Over his door was written, "Joseph Whitworth, tool maker, from London," and this was the beginning of the great works which have since achieved world-wide renown. When he introduced his true planes into his own workshop, the workmen did not conceal their prejudice in favor of the old method of planing, but a very short experience taught them that the new process was a much quicker and more reliable way than the old. The new planing machine may be said to have come perfect from its creator's hands, for since its first construction it has continued to be made to this day without any alteration in principle. The development of the principle of the slide followed the construction of true planes, the one being in fact an extended application of the other. Simple as the slide now appears, its application to the construction of machines to an extent that has not found a limit, has only taken place during the last forty years, for though the principle itself merely consists in so forming two adjacent plates as parts of a machine that one of them can slide freely upon the other, it required years of skill and ingenuity to work out its application in complicated machines, and its effect in facilitating the operations of the workshop might be regarded as next in importance to the introduction of the steam engine as a source of motive power. It gave birth to a better and happier age. The improvement of the screw was another important step in the same direction. Early impressed with the necessity of improving the guiding screw in the lathe, Whitworth determined to accomplish this desideratum. He got rid of fractional measurements, and made the screw as perfect as possible. In the guiding screw, 30 ft. long, there were two threads in the inch, and he worked upon it every day for six months, making it take out its own errors. As then perfected, it has remained ever since, and the standard is one of the most important as well as one of the nicest applications of mechanism. It took a long time to do it, but now every marine engine and every locomotive in this country has the same screw for every given diameter. In his early years there was no means of knowing when they had a screw that was absolutely correct. By his multiform applications of the true plane, the slide, and the screw, he enabled mechanics to work with a facility, precision, and cheapness hitherto unknown; but to insure the perfection of such work, exact uniformity of manufacture and reliable means of testing this exactness were still wanting. This is one of his simplest and yet most valuable inventions, and which is best described in his own words: "The measuring machines which I have constructed are based upon the production of the true plane. Measures of length are obtained either by line or end measurement. The English standard yard is represented by two lines drawn across two gold studs sunk in a bronze bar about 38 in. long, the temperature being about 62° Fahr. There is an insurmountable difficulty in converting line measure to end measure, and therefore it is most desirable for all standards of linear measure to be end measure. Line measure depends on sight aided by magnifying glasses; but the accuracy of end measure is due to the sense of touch, and the delicacy of that sense is indicated by means of a mechanical multiplier. In the case of the workshop measuring machine the divisions on the micrometer wheel represent ten thousandths of an inch. The screw has twenty threads to an inch, and the wheel is divided into 500, which multiplied by 20 gives for each division the ten thousandth of an inch. We find in practice that the movement of the fourth part of a division, being the forty thousandth of an inch, is distinctly felt and gauged. In the case of the millionth machine, we introduce a feeling piece between one end of the bar to be measured and one end of the machine, and the movement of the micrometer wheel through one division, which is the millionth of an inch, is sufficient gravity. The screw in the machine has twenty threads, which number multiplied by 200—the number of teeth in the screw wheel—gives for the turn of the micrometer wheel the four thousandth of an inch, which multiplied by 250—the number of divisions on the micrometer wheel—gives for each division one millionth of an inch. The sides of this feeling piece are true planes parallel to each other, and the ends, both of the bars and the machine, are true planes parallel to each other and at right angles to the axis of the bar; thus four true planes act in concert. In practice we find that the temperature of the body exercises an important influence when dealing with such minute differences, and practically, it is impossible to handle the pieces of metal without raising the temperature beyond 60°. I am of opinion that the proper temperature should be approaching that of the human body, and I suppose that 85° Fahr. should be adopted, and that the standards and measuring appliances should be kept in a room at a uniform temperature of 85° Fahr."

From these primary inventions a whole progeny of tools, gauges, and machines were produced for drilling, shaping, slotting, and numerous other purposes; and as the result of these manifold improvements the production of machinery has multiplied during the last forty years to an enormous extent. By the exactness and uniformity of manufacture which have been attained by his improvements we can now supply in any number the component parts of a machine which are perfectly interchangeable. For example, fifty years ago the thousands of spindles in a cotton factory had each to be separately fitted into the bolster in which it had to work. Now all these spindles are made to gauge, and are interchangeable. As an example of the efficiency attained by these improvements, take the duplex lathe, which he designed and perfected, and which he has almost exclusively adopted at his own works. By means of it the prices of work were reduced 40 per cent., and in addition to that 40 per cent. more work was produced.

In 1854 Lord Hardinge invited Whitworth to assist him in investigating the mechanical principles involved in making a good rifle; and henceforth he devoted his attention to this subject. The Enfield rifle was then the favorite weapon. It had a bore of 0·577 in., and the rifling had one turn in 78 in. After a series of experiments with the view of finding out the effect of increased twist in the rifling, Whitworth came to the conclusion that the best twist for a rifle bullet was one in twenty, with a minimum diameter of barrel of 0·45 in. In the Enfield the bore was cylindrical, with grooves; in the Whitworth it was hexagonal, with the edges rounded. Experiments made in 1857 to test the power of this weapon showed its vast superiority in accuracy, penetration, and range; and it was then considered a great feat of arms when in 1860 the Queen inaugurated the first prize meeting of the National Rifle Association at Wimbledon by hitting the target within 1¼ in. of its actual axis, at a range of 400 yards, with a Whitworth rifle. Applying similar principles to ordnance, he produced guns of greater efficiency than had ever been known before, and their fame was soon spread abroad. In 1863 the *Times* correspondent with the Confederate army in America stated that it was impossible to praise too highly the performances as a field piece of the 20-pounder Whitworth. "There is no other gun on the continent," he added, "which can compare with its lightness, precision, and length of range. Again and again, one single Whitworth gun has forced Federal batteries to change their position, and eventually to fall back. There has been more joy among the ordnance officers over the arrival of five more Whitworth guns which have just arrived safely at Wilmington than there would be at the capture of a hundred such guns as were in position on both sides at the battle of Fredericksburg." The renown of these guns became so universal that the inventor received overtures from almost every government in Europe to be supplied with them. In 1864 the British government arranged for an elaborate series of experiments to take place at Shoeburyness for the purpose of testing the relative qualities of the Whitworth and Armstrong guns. The competition was divided into thirty-four stages, and upward of 2,500 rounds of shot and shell were fired. The committee of artillerists, after much deliberation, reported that they could not determine which was the superior gun. Though Whitworth's ordnance then failed to be adopted by the British government, his guns continued to be freely exported to other countries, while not a single Armstrong gun went abroad.

In 1868 Whitworth again astonished the world by producing a gun which could throw projectiles further than they had ever been thrown before. Its range was 11,243 yards with 250 lb. projectile, and 11,127 yards with 310 lb. projectile; in other words, a mass of 2¼ cwt. of iron was hurled a distance of 6½ miles. In 1870 a 9 in. armor shell weighing 4·4 lb., made of steel, was fired a distance of 200 yards against the War Office shield, which was composed of three 5 in. iron plates interlaminated with two 5 in. layers of iron concrete, the whole forming a prodigious mass 25 in. thick. The shell buried itself in this iron wall—indeed it may be said to have penetrated it—a result which was then considered almost impossible. Since then he has continued his experiments, and has from time to time made further improvements in his guns. His attention during the last few years has been directed to the mechanism of breech-loading, and the enlargement of the powder chamber in order to increase the ranges. A complete explanation of his improvements in the weapons of war is more interesting in a military than in a biographical point of view; we have therefore only given a few of his most striking achievements; but great as these were in their results, they give no adequate idea of the extent of the inventor's labors in this department of mechanical skill. As in his improved workshop appliances he constructed standard gauges, gave uniformity to the screw, and showed the necessity as well as supplying the means of measuring with precision the most minute parts of machinery, so with regard to the military art he elucidated by numerous experiments many useful and previously unknown principles as to the flight and form of projectiles, the diameter and rifling of guns, and the best means of enduring power of penetration. On these subjects he has elaborated from his own experiments precise data and worked out with mathematical exactness many perplexing problems, which, even if his guns should be superseded in the future as all others have been in the past, must have a permanent influence upon the development of the military art. In his own country his labors as an artillery inventor and the mechanical principles which he has applied to the construction of ordnance have not been too highly appreciated. The government authorities have pronounced his system of rifling to be "the most expensive and complicated of all;" but notwithstanding their decision in this matter, it may be truly said that he has not been without honor save in his own country.

However much opinions may differ as to his system of construction, that is not the only improvement he has introduced into our gun factories. In the earlier years of his artillery experiments he found that the terribly destructive weapons he was creating required a better metal for their construction. All guns were then made of iron. It was the common belief till then that steel was an unsafe material to use for ordnance. He, however, turned his attention to the adaptability of steel for the purpose; but believing that its existing qualities would have to be improved before the prejudices of the period could be overcome and tests required could be satisfied, he determined to effect this improvement. The Bessemer steel then made was hard enough, but it did not possess the requisite ductility and soundness. Ductility was indispensable, but it could not be got without forming air-cells which made it unsound. On splitting open a large ingot of the best Bessemer steel, he found the upper part full of air cells. The only mode then used for working steel so as to render it close, strong, and ductile was to compress it when in a solid state by expensive machinery. Convinced that this process could be improved upon, he began to make experiments with that object steadfastly in view; but it seemed a Herculean task. Between 1863 and 1865 he labored almost incessantly at this work, and in the latter year he succeeded in attaining his end, his ultimate success being the result of 2,500 experiments. His process simply consisted in subjecting the steel in its fluid state to such a high pressure that the air or gas bubbles were pressed out of it. He found that a pressure of not less than six tons to the square inch was required, and that under that pressure a column of steel was compressed to the extent of 1½ in. per foot of length. At first he experienced many failures; and not his least difficulty, after evolving the principle of his process, was the making of materials and machinery capable of resisting such enormous pressure. At first he was obliged to make comparatively small presses for compressing the steel, and then gradually to increase the size of his apparatus, thus building up and extending the process till he found that it could be employed with safety and certainty in the production of articles of any required size, such as propeller shafts and cylinder linings for the largest marine engines, ordnance of large caliber, and torpedo chambers. At last he made what was known as the 8,000 ton press. In his own works, where the steel was made, the workmen were so afraid of the consequences that might result from the application of such enormous pressure to fluid steel, that they always ran away when the pressure was put on in order to be secure from the risk of accidents. Nor was this his only discouragement, for while the workmen were frightened, the critics were laughing at the invention. If the fluid steel were compressed in moulds of such great strength as to resist the requisite pressure, where could the air and gas bubbles escape? If, they argued, there was no way of escape, they must be still in the steel. Science was baffled to explain how it was done, but the result of the process was nevertheless apparent. When tested along with the best metals hitherto made, it was found superior to them all in strength and ductility. Damascus steel burst with a charge that compressed steel resisted. His field guns are now forged solid, and then bored and rifled, the trunnion hoops being screwed on. In making steel propeller shafts there is a great saving in weight when this metal is used. In the case of the Inflexible, a weight of 34 tons was saved, and the strength of the shaft was greater than any other metal would have given. When Mr. E. J. Reed was chief constructor for the English Admiralty, he expressed to Sir Spencer Robinson his conviction that "the Whitworth metal is superior to all other existing steels for the manufacture of ordnance. In no branch of manufacture has the want of soundness and uniformity in steel been more severely felt than in this, and in none is a superior steel more essential. . . . No one who has considered the process of Sir Joseph Whitworth and has examined the steel produced by it can, I think, doubt for a moment that it is a more close, a more compact, and a more perfect material than any other description of steel in existence." Few would now dare to dispute the general accuracy of that opinion, but at the time it was uttered few men in high official position were so bold as to assert it. Sir Joseph's own accounts were more definite. He conducted a series of experiments on small cylinders of metal 2 in. long, and having an average section of half a square inch; these he tore asunder by hydraulic pressure, and the difference in length before and after this strain gave the elongation and ductility of the metal. The conclusion he arrived at was that, taking the tensile strength per square inch of the best iron as 27 tons, with a ductility of 38 per cent., and that of ordinary cast iron as 10 tons, with a ductility of 0·75 per cent —high standards of comparison—steel compressed by his process gave from 40 to 72 tons of strength and from 32 to 14 per cent. of ductility. Another test used by him was equally convincing. He took a small cylinder like a gun-barrel, and having firmly plugged it at both ends, he fired a charge of gunpowder within it. It took six explosions, with an aggregate quantity of 250 grains of gunpowder, to burst such a cylinder, and even then it remained in one piece. In that way it has been shown that a cylinder of compressed steel is capable of enduring 48 explosions, of 24 oz. each, of gunpowder, while a similar cast iron cylinder burst in 20 pieces at the first discharge of 3 oz.

The process for the manufacture of compressed steel was patented in 1865, but it was not till 1869 that Sir Joseph got his apparatus completed and was in a position to manufacture his steel in quantities fit for use in his works. The patent accordingly died last year, but the Judicial Committee of the Privy Council, in consideration of the cost and usefulness of the invention, agreed to prolong it for a further term of five years.

England has been prolific in inventors, and one of the most prolific of them has been Sir Joseph Whitworth. What she has been regarded as behind her neighbors in was the technical education of her skilled artisans; and no man has done so much as Sir Joseph Whitworth to supply this deficiency. When the great International Exhibition was held in Paris in 1867, many Englishmen of eminence in science and industry expressed their strong impression from the evidence then afforded that the mechanics and artisans of continental countries were by virtue of their superior education advancing at a greater rate of progress than the same classes in England. Dr. Lyon Playfair, who had acted as a juror in the exhibitions of 1851, 1862, and of 1867, addressed a letter to Lord Taunton, the chairman of a school inquiry commission, that sat in the latter year, with the view of arousing attention to the backward state of technical education here. That letter was widely circulated, and elicited many corroborative opinions; but the subject seemed to be again declining in interest, when in the following year Whitworth, then the acknowledged leader of the mechanical engineers of this country, announced to the Prime Minister his intention of founding a series of scholarships for the encouragement of young men in scientific and technical education. He offered a sum of £100,000 to found thirty scholarships of the annual value of £100 each, and he asked the Committee of Council on Education to undertake the necessary examinations. This announcement was made in May, 1868, and the first examination of candidates being fixed for May, 1869, he undertook to establish sixty exhibitions or premiums of £25 each, to be held for one year, with the view of enabling competitors

to have twelve months' preliminary training for the scholarship's examination. This scheme is the most munificent of its kind, and the need there was for it was proved at the first technical examination, which the donor personally conducted. Of the 106 candidates presented, 53 were exhibitioners, and 54 failed to pass the preliminary examination. Of the 53 who were allowed to stand the technical examination, the number that possessed the requisite minimum of knowledge and skill were just about equal to the annual number of scholarships. The exhibitioners were the most successful competitors. In succeeding examinations experience suggested various modifications of the scheme. Thus, to make sure that candidates were really devoted to mechanical engineering, each was required to produce a certificate to show that he had worked in an engineering shop for two years; annual examinations of the holders of scholarships were instituted to insure that they were making the degree of progress which was made indispensable, and to encourage them to make the utmost possible progress gratuities ranging from £20 to £100 were awarded according to the order of merit to the six scholars who showed the greatest proficiency, while at the end of the course the scholars who stood highest at all the examinations received an additional reward of £200, and the next best £100. It is thus possible for one young man to receive £800 altogether in three years.

Of this eminent benefactor, Mr. Gregory, the renter warden of the Turner's Company, and the late president of the Institution of Civil Engineers, in presenting the freedom of that guild to him in 1875, said: "Well has he merited fortune, fame, and honor. Raised by his sovereign to rank and title, he has been honored by other men of science with the distinctions of D.C.L. and F.R.S. He has devoted a noble share of his well-earned fortune in munificent endowments for the higher education of mechanical engineers. When he is taken from us he will leave his monument in the workshops of the world; and as monks of old sang requiems over the graves of departed heroes, so young mechanics, trained by his liberality, will keep the name of Sir Joseph Whitworth green in their grateful memory for all time."—*Universal Engineer.*

AUBURN PRISON.

SOCIAL relations are as distinct among criminals as among honest men, and it is not a little amusing as well as interesting to note the severity with which the lines are drawn. Forgers, bank robbers, bank burglars, "false pretense men," and an exceptional class of murderers form the "upper ten." Housebreakers, highwaymen, and the like, are rated next, while men convicted of rape and other depraved crimes must walk in the lower circles. A "high-toned" convict would not deign to converse with a meaner prisoner, much less to associate with him. In the workshop and mess-room, at services, and going to and from the cells, this difference in station may be observed. The aristocrat holds up his head in the consciousness of his supremacy, while the lowly one shuffles along in a dejected manner. The aristocracy, strange as it may seem, are not disliked by the humbler prisoners, but on the contrary, are respected.

Perhaps the most aristocratic convict that ever wore the prison garb was William G. Gilman, the insurance scripraiser from New York. He could not find it in his nature to place himself on a level with the beings about him, and held himself strictly aloof from them. One afternoon the writer entered the office of the State Agent for Discharged Convicts, where Gilman was employed as clerk. The man seemed glad of an opportunity to converse with some one from the outside world, and talked long and earnestly. When Marie Roze sang to the convicts in the prison chapel, Gilman, who was an adept in the use of the pen, prepared an embellished card, bearing a quotation from Tennyson, which was so applicable to a person shut out from the world that Marie Roze inquired after the man. She was told of his position and his offense, and evinced a deep interest in him. She accepted the card and returned a graceful expression of sympathy.

Joe Coburn, the pugilist, is an aristocrat. He occupies the place of "deputy's waiter." A part of his duties is to apply the paddle to refractory convicts. Joe's physical development enables him to wield the instrument of correction with salutary effect. Coburn looks after the office of the deputy agent, or head keeper, but his task is an easy one on the whole.

The lawyers are looked upon as "great men" by the prisoners, and words from their lips find endless repetition among the other prisoners.

Stone, one of the famous Canastota "firebugs," is pointed out as a "prominent" convict. He is a keen, perceptive man, and exerts a great influence over the men. He is at present serving in the capacity of chaplain's waiter.

King, a lawyer from New York, a "life man," is shrewd but deceitful. The prisoners respect him, but at the same time are distrustful of him.

"Dan" Kelly, the bank robber, once escaped from Auburn prison, and is now carefully watched. On account of his escape he is the idol of the convicts, although he will have nothing to do with them.

The lowest man that ever entered the prison was an old negro named "Frank." He served half a dozen terms, all for rape, and was despised by every man in the institution. He died about a year ago while serving a sentence.

Envy is a rank element of prison life.

There are many "desirable situations" even in a prison, and the strife among convicts to secure these places is astonishing. The position of waiter is a particularly good one. A waiter's duty consists of taking care of the shop, office, hall, or wing where employed. There is but little to do, and the convict is enabled to read, chew tobacco, and talk to his heart's content. A place as attendant in the hospital is one of the best in the prison. The convict has many opportunities to secure a dish of milk or some delicacy purchased for the patients. The men in the hospital live like kings, so to speak, and enjoy many advantages that the convicts in the shops never know. The kitchen is a place much sought after, as the men can once in a while make little dishes for themselves, such as they would not otherwise obtain. There are convicts who possess more influence with the officers than would be imagined, and not infrequently they exercise it in securing a position.

Gambling is carried on to a great degree. The convicts do not use cards, as one would suppose—these are too liable to detection. They bet on events—changes in the weather, the time of day, and everything of that character. They also "odd and even," "flip," "match," "roll," "throw for the crack," and the like. Convicts are not supposed to carry money, but they do just the same, and sometimes considerable sums. As they are carefully searched and their clothing taken from them, the men cannot take money into the prison with them: they obtain their money usually from friends who visit them.

They sew their money up in their clothing, and it is seldom that it is discovered. Occasionally a man will be found with ten or twenty dollars in coins in his coat collar or other parts of his clothing.

There are pawnbrokers and money lenders. These criminal Shylocks are more exacting than the "uncles" of the street. The convicts "put up" some trinkets, which they mostly all have, or pledge something else to get a few dimes or pennies.

Gambling is the great evil, but it is the only exciting pastime the convicts have. If a keeper or guard can be "bought," the convicts will pay him a good salary right along to perform services for them, such as bringing in papers, tobacco, and edibles, and taking out letters. Some convicts keep up a regular correspondence with friends outside. The letters "pass through the underground," as the officers term it. A convict prevails upon the foreman of his shop, who is always an outsider, or some citizen, as there are many of them employed in the fine work in the prison, to carry out his letters and bring back the answer. Thus letters go in and out.

The New York morning papers reach Auburn at 4 o'clock in the afternoon, and the same day the convicts may be found reading the news of the day "on the sly," in their cells. How the prisoners secure the newspapers is a mystery to many. The foremen of the shops, or perhaps the officers, bring them in. The convicts will give a good deal for New York papers, and they will have them at any price. The prisoners keep well posted on the events of the day, and discuss with intelligence any subject that is being treated in the papers.

If there is one thing more than another that a convict likes to do it is to "trade." The men are bartering constantly, and some become possessed of considerable "property," which, however, they must at all times keep concealed.

Not so very long ago an enterprising convict established a distillery in the prison and engaged in the manufacture of liquor. He excavated beneath a stone in the floor of the kitchen, where he was employed, and set a small tube in the hole. With hops used in making yeast, and corn and barley used in making bread and soup, he produced a potation that would intoxicate. Drunkenness became quite prevalent, and finally the distillery was discovered and the "moonshiner" put in the prison jail on bread and water. While he ran the distillery he did well, and would in a short time have been comparatively wealthy.

"Beer," as it is called, is made to this day from the bread crusts, but the makers have to exercise caution.

One man raised a quantity of tomatoes on the window-sill of his shop and sold the crop for a large sum.

Smoking, although strictly prohibited, is indulged in at night after the men are "locked."

A spell ago a watch was taken from a man. The convict carried it in a leather bag suspended in his pants leg by means of a string. The convicts pin things inside their clothing to keep them from the officers, and carry knives and other implements in their hats and shoes.—*Syracuse Courier.*

THE BOTTLE BUSINESS.

REPRESENTATIVES from a majority of the sixteen New Jersey bottle and lamp chimney manufactories have been lately canvassing the Boston market, soliciting orders for delivery in the winter and early spring. Makers of the chimneys are asking an advance of twenty-five per cent. on last year's prices, and talking very enthusiastically of soon putting on another twenty-five. This advance would not have much effect upon the consumer, as at the outside the jobbers would be able to supply their trade at three and five cents each, while the present retailing price, five and eight cents, gives sufficient margin for the last seller's profit even on an advanced cost.

The Boston chimney trade is considered better than that of any Atlantic city, not only on account of its volume, but because of the preponderance of the best. From the estimates of these folks it would appear that on an average Boston will find a sale for not less than 300 barrels a day from July through to February, although some figure a steady market here of 500 barrels a day. Each barrel contains seven dozen, costing to lay down here now about $2.85 a barrel.

The leading item in common glass is lager beer bottles; of these Boston this season consumes over 15,000 gross. In fact, it is the largest market in the country, and at the Long Branch glass makers' meeting two weeks ago, it was unanimously agreed to give the Boston dealers a special discount, which, as one present stated, was to hold the Boston market from being consolidated upon one factory. This year Boston has been by far the lowest priced point. Last summer the demand for beer bottles increased fifty per cent. over that of the summer of 1878, and our local dealers, fearing a short stock for this summer, and hearing rumors of an advance, placed orders for about 20,000 gross just before the annual shutting down. At that time the factory price was $5 a gross, but with the September start up, and the influence of the general boom, the makers advanced to $11, at which price, it is stated, two-thirds of the lager beer bottles in other cities have been supplied.

The increased demand for lager bottles was noticeable throughout the country, and as each bottle takes a pound of green glass, the prices on all common glass goods have been advanced since September, 1879, from forty to fifty per cent., while flint or white glass is not more than ten per cent. higher. Lager bottles hold fourteen ounces of liquid, and if the prognostications of the makers is to be taken, next year Boston will want 25,000 gross. The demand for mineral water bottles has fallen off. Three years ago the sales were about 4,000 gross, having slid down from 6,000 gross in two years, where the annual consumption had ranged for eight or ten years. This year it is doubtful if 1,000 gross will be sold, and for next year possibly the old junk dealers may be able to find the bottlers all they require.

This second-hand bottle business is growing into noticeable prominence, especially since the introduction of tonic beer and the utilizing of champagne bottles for serving it. These champagne bottles bring from 35 to 40 cents a dozen, and the sales aggregate about twelve thousand dozen this season. The height of the season is just before Independence Day, when every cellar is scoured for its old champagnes, and the price works up to and above 50 cents a dozen. Just now the empty bottles are coming in again, and after washing are being packed and shipped to cider bottlers, who this fall are likely to want 20,000 to 30,000 bottles. The apple crop is large, and cider will be cheap and profitable bottling.

The old lager bottles are chiefly sold West. They are collected without reference to brands or stamps, are apt to be nicked and the wire stoppers rusty, hence for the household, into which two-thirds of the New England bottled lager is delivered, these untidy bottles are objectionable. They are packed in hogsheads holding 50 dozen each, and if the wire and rubber stoppers are in workable order, bring 80 cents a dozen. The new bottles with new wire stoppers have been selling this summer at $12.85 a gross, which is about $1.07 a dozen. This is an advance of only $1.85 on the lowest price of last year, and is from four to seven dollars a gross less than some other markets have afforded them this year. The wire fastening and the rubber stopper is the invention of a New Yorker, and it pays him a royalty of two cents for each one put upon a bottle. They cost $6 a gross, which a year ago was more than the bottles cost. The income from this patent is said to be worth $25,000 a year.

Boston leads on the consumption of radish bottles, which for three or four years back has been annually 10,000 gross. Last year these cost $2 a gross, but now they are $4.20 a gross, and as the market will sustain no advance in the radish when put up, this increased tax is quite a burden to a number of bottlers. Pint pickles and tomato catchups have a limited sale, possibly about 400 cases of ten gross each. The sales of fruit jars from Boston have always been large, but this year the demand is lighter, owing both to scarcity and high prices. Bottles that were obtainable in 1879 at $7 50 a gross are now $16.50. Philadelphia is the leading market for fruit jars, as it is for mineral bottles; of this latter the annual sales are over 15,000 gross.

New York's specialty is demijohns. While Boston uses about 30,000 a year, chiefly in gallon and half gallon sizes, New York will take 300,000 in gallons alone every year, and half as many more in half gallons. Some of the leading makers set the demijohn trade in New York as equal to 700,000. The stone jug is rather popular in New England, but they are said to be gradually yielding to the wicker covered glass. The poorest qualities of glass are put into demijohns. If a furnace is found to have been mixed and melted of too poor a character for lager or fruit jars it is turned into demijohns, although the lines furnished patent medicine men are available in the cheapest stock. Manufacturers say that eastern New England contains the largest buyers of patent medicine bottles. The orders of three or four are said to aggregate for each yearly over $50,000.

The old bottle business is quite a feature in Boston, and is carried on with all the details of assortment and fluctuations in prices that beset other interests. There are about 28,000 pint English ale bottles shipped to New York yearly from Boston, that just now are worth 1½ cents each, while the quarts are salable only on the reception by a Gothamite bottler of a special order, and are held in stock here for ¾ cent each. The stone Scotch ale bottles sell largely West at 10 cents a dozen, "free on board." Rhode Island furnishes a good market for salad and sweet oil bottles, whither they go to be refilled with an American imitation of the Spanish article. The largest lots come from New York and Chicago, and are worth, in 4 ounce 12 cents and 8 ounce 15 cents a dozen. New York reaches out for all the old brandy and gin bottles of straight continental make, paying 36 cents a dozen for the former and 60 cents a dozen for the latter. Last fall gin bottles were scarce, and as high as $1.10 was paid, but the winter consumption of the juniper juice is large, and the bottle stock augmented and broke the market down to 50 cents. Within two months there has been a recovery of 10 cents.

Boston is a favorite market for Gothamite bottlers of imitation spirits, as it is here that the largest consumption of genuine foreign favorite brands of high cost is said to occur. Until this year, a thousand clarets were considered a good season's pickup, but this season one dealer has packed 3,000, and thinks he will have twice as many more when the summer resorts clean up in October. These are now held at 40 cents a dozen for quarts and 18 cents to 20 cents for pints, according to the style, certain foreign claret brands having peculiarities in their bottles, which bottle buyers are willing to pay a premium for. The flat-bottomed, long-necked, thick black glass, Apollinaris bottle is the only medicinal spring water bottle that has a market, and these are collected by the junk dealers, about 300 a month, and sent to New York. The bulk of these that are "unloaded" are said to be returned to the dealers who sell the water. The bottle dealers ship them at 20 cents a dozen.

New York picks up about 3,000 quart English pickles and about 7,000 pint, paying 36 cents a dozen for the quarts and 30 cents for the pints. These go to the chow-chow folks who bottle imitation foreign stuff. Second hand flasks are sold in dozen lots almost as fast as received, and come in regularly from all parts of New England in 30 to 60 in a barrel. The bottle people have retailing customers who will take weekly from 75 to 200, while one retailer averages 350 a week in the several sizes. They pay for half pints 30 cents, for pints 36 cents, and for quarts 40 cents a dozen. Ink bottles are collected in countless quantities. None of the dealers will undertake to estimate the number. They clean and sell them at 18 cents for pints and 24 cents a dozen for quarts. In prescription bottles the second hand lots average about thirty per cent. under the cost of new, and are largely sold to lotion, liniment, and bluing folks. One dealer has now on hand a stock of 400 barrels.—*Boston Advertiser.*

RECIPROCAL DISPLACEMENTS OF THE HALOGEN ELEMENTS.

IT is well known that chlorine displaces iodine and bromine, and that bromine displaces iodine in metallic combinations; all these displacements are conformable to the thermic theory. The inverse displacements could not be executed under the same conditions, but they may be accomplished under special conditions, either by means of the dissociation of primitive compounds, or even, when these compounds are stable, through the formation of secondary compounds, such as the chloride and bromide of iodine, the triiodide or the tribromide of potassium, or even the two chlorides of iron, of mercury, of copper, etc. When the compounds formed by the halogens are dissociated complete transformations are conceivable, following two opposite directions. Berthelot has shown that such transformations are possible in consequence of the dissociation of the secondary compounds, through a very interesting thermal mechanism, which he discovered by studying the inverse displacements of oxygen and of chlorine when united to arsenic, and of oxygen and iodine when united to potassium. It is necessary that the formation of the secondary compounds should set free a quantity of heat superior to the heat which is absorbed by direct substitution in the compounds of the first order. The substitution is also possible if the temperature be raised to the point when the metallic chlorides, bromides,

and iodides are dissociated, because the halogen element may then act upon a portion of the free metal; the opposite element, being partially removed in the meanwhile, is not present at the moment of cooling to reproduce its primitive combination. This second substitution, however, has not yet been accomplished without the intervention of the accessory influence of air, moisture, and the constituents of glass.—*Comptes Rendus.*

PROGRESS IN FIRE EXTINGUISHMENT.

At the time when, within a few years, steam power was brought into play in the operation of fire engines, it could hardly have been anticipated that farther improvement was possible, or desirable, beyond the perfection of the enginery thus added to the lists of its conquests by this motive agency of our material civilization. And, indeed, in contrast with the hand engines of other days the steam fire engine might seem to mark the final step of progress in this direction. When, in addition to this, we consider the system of municipal fire organization, with its prompt and facile working method, seconded by the instant omnipresence of the electric signal, it should almost seem that the mind not stubbornly bent on wondering at nothing and content with *nothing*, must look in some other direction for needed and practicable results of inventive skill. Assured as has been our progress in the fire enginery, now so nearly perfected, equally certain it is that even greater progress is yet to be made. And if, in the nature of the case, such progress cannot consist in the improvement of present methods, then it must be radical. In all the steps leading to the present improved system—from the voluntary use of buckets and hand engines by the bystanders to the compact fire departments of to-day, with their complex and powerful engines—there has been, what we are now beginning to discover to be, a radical defect in the principle. We mean the assumption that fire must be fought with water. It does not seem, until recently, to have occurred to the scientific mind, casting about to discover and utilize some natural force other than steam, powerful enough to draw the railroad train, propel the ship, and throw the water to great height and distances, that there might exist in the mysteries of chemistry—nay, at our very hand—some product which, far more effective than water, should at the same time itself be less destructive to property, more adequate in proportion to its weight and value, and therefore more portable and manageable.

And right here we may best draw attention to one of the most inconvenient and injurious results of the use of water. It is an acknowleiged fact that of the large losses by fire in the United States and Canada, a very large percentage is due to the destruction of goods by water. Indeed it is generally true, in case of the partial destruction of a building by fire, that the water used in extinguishing the flames causes nearly as much damage as the fire, while almost always the preservation of a building from more than a few hundred dollars' damage by fire, is attended with thousands of dollars' damage to the stock from flooding. And there is hardly anything which water will not more or less injure—most goods, irreparably. This drawback, serious as it is, only barely surpasses others inseparable from the use of water. Principal of these—and we pass them by with a mere mention—are, in many cities, the almost impossibility, and in all the inconvenience and expense of assured water supply and adequate distribution the year round; and the difficulties, often insuperable, attending its use in periods of excessive cold. Upon all these points we have frequently dwelt, in articles urging the increase of our water supply, the erection of capacious reservoirs, and the laying of pipes and putting up of fire hydrants in those thickly peopled areas beyond fire limits in every direction where are the houses of the great bulk of our population.

The introduction of an extinguishing gas—carbonic acid gas seeming best adapted to the purpose, both by reason of its superior efficiency and its easy and comparatively inexpensive manufacture—is, it may now be confidently assumed, to work the revolution which has at length become imperative. Whether this or that system or whether any system among those recently introduced will be practicable and of general vitality remains to be seen; that some adequate system of using so powerful an extinguisher will be devised and generally introduced, we think a foregone conclusion. The results of its use with portable hand machines have been so signal that encouraging efforts are now making looking to its introduction on a larger scale. At one time it was proposed, not very long ago, to erect large manufactories and reservoirs of the gas, with pipes laid to every part of the city, and, if need be, to every building. The projectors of the scheme devoted themselves assiduously to the work of preparing plans, and their efforts were attended with considerable success; in that many ideas before unknown were evolved. The increase from the manual pressure of five pounds to forty pounds to the square inch was provided for by a simple piece of mechanism attached to the conduit. The facilities of its use, due to its superior density as compared with common air, also filled those engaged in the labor with hope. That some have failed to accomplish the end sought, or have, at least, desisted from their efforts, should not dissuade others from working in the same direction. The feasibility of introducing it in this manner and its adequacy once established, all details will follow, as a matter of course, relating to its management, in warehouses, stores, and public buildings, by the authorities, and its application by the occupants themselves to an incipient fire in less time than was required to reach an alarm box and set the bells to ringing up the fire department force. This, especially, if the aim were to combine with a thorough municipal system the introduction of portable extinguishers, like those now in use, into public and private buildings. The success that has attended the use of dry carbonic acid gas at New Orleans for the extinguishment of fires on shipboard seems to point to further developments of the value of this plan for fire extinguishment.—*Fireman's Journal.*

VOLUMETRIC DETERMINATION OF LEAD.

By W. Diehl.

The author employs a one-twentieth normal solution of potassium bichromate containing 7·38 grammes per liter, each c.c. representing 0·01035 gramme lead, and a solution of sodium hyposulphite, containing 4 to 5 grammes per liter. To determine the relations between these two solutions, 20 to 30 c.c. of the bichromate are run into a flask, diluted with 300 c.c. water, and mixed with 20 to 25 dilute sulphuric acid (1 vol. monohydrated acid and 2 vols. of water). A certain excess of sulphuric acid is indispensable, hydrochloric acid being less convenient.

The liquid is brought to a boil, and the solution of hyposulphite is added drop by drop. The solution becomes gradually paler in color. Toward the end, after the addition of a few drops, it is let boil up again. The end of the reaction may generally be distinguished by the liquid turning perfectly colorless, a result occasioned by a single drop. In order to judge of the color, the flask, toward the end of the operation, may be set in a porcelain capsule. When very large quantities of bichromate are used the liquid does not become perfectly colorless, but slightly greenish.

In determining ores in this manner they are dissolved in *aqua regia* and dilute sulphuric acid, the solution concentrated till the sulphuric acid begins to evaporate, diluted with water, boiled to dissolve ferric sulphate, let cool, and filtered through a smooth filter, washing with water containing sulphuric acid. To the residue in the flask—as little as possible of which is thrown upon the filter—is added about 15 c.c. of a solution of neutral ammonium acetate, and about 50 c.c. of water. The whole is then boiled, and filtered through the same filter into which a drop of ammonia has been put, into a flask. The same operation is then repeated with 5 c.c. ammonium acetate, and the residue is finally well washed with boiling water to which a little of the same salt has been added. Thorough washing is necessary, since filters have been found to retain ammonium lead acetate and tartrate with considerable obstinacy.

It is then advisable further to wash the filter from its margin downward with a little boiling dilute hydrochloric acid (1 part hydrochloric acid at sp. gr 1·12 with 10 parts of water), and then to wash again with hot water. In this manner every trace of lead is removed from the filter. A thin filter paper should be used, and should be washed previously. The solution of lead sulphate in ammonium tartrate thus obtained is then titrated in the cold with potassium bichromate; with the aid of heat ammonium acetate dissolves a little lead chromate. The precipitate settles readily if the flask is shaken, and the end of the reaction can be observed to within 0·2 to 0·4 c.c.

An excess of at least 2 c.c. of the chromate solution should be added in order to obviate the solubility of the lead salt. It is advisable in every experiment to take as closely as possible an equal quantity. After thoroughly shaking, it is allowed to stand for half an hour and filtered. If the liquid passes through turbid, a few drops of a solution of sodium acetate acidulated with acetic acid are added. If, after all, a little lead chromate passes through the filter, the filtration is repeated. The precipitate is washed four times with cold water, and the solution is acidulated with sulphuric acid and titrated as above.

Ammonium acetate is preferable to all other ammonium salts as a solvent for lead sulphate. It is applied in a neutral or faintly acid state. Free ammonia renders the solution turbid. 1 gramme lead sulphate requires 15 c.c. of the liquid acetate for solution. Ammonium tartrate cannot be used.—*Zeitschrift für Analyt. Chemie.*

THE PREPARATION OF GELATINE-BROMIDE.

By M. Bascher.*

I first dissolve in the water-bath, heated by a nightlight

Water	275 parts.
Nelson's No. 1 gelatine	30 "
Bromide of ammonium	7 "
" zinc	1 part.

Generally, sufficient importance is not attached to the soluble bromide employed. That of ammonium gives very good results, but the negatives are often gray; it is to avoid this inconvenience that I add the bromide of zinc, which gives sharp and brilliant images. Bromide of lithium causes the film to adhere firmly.

While the preceding solution in operation I prepare that of nitrate of silver:

Water	50 parts.
Nitrate of silver	12 "

After mixing both, I leave them in the water-bath for three days. At the end of that time I pour the whole into a flat dish to set in a cool place; in summer, ice is sometimes necessary.

The gelatine, having set, is squeezed in a coarse cloth, and the shreds thus produced are plunged into a basin of cold water. I pour them on a sieve, by the aid of which I steep them in water several times renewed. I leave them to drain for a quarter of an hour, then wash in methylated spirits until the fragments become hard. They are then spread over a glass previously waxed and allowed to dry thoroughly, which takes about twenty hours. This dried emulsion is kept in cardboard boxes. In using, I dissolve it in water slightly alkaline in the proportion of 1 to 10, and spread it by means of a glass rod on plates previously coated with a 4 per cent. solution of white of egg to which sufficient chrome alum has been added to give it a bluish tinge. This substratum has great adhering properties.

The dry plates are packed up, and may be preserved for a long time away from the light and damp. The exposure is very quick; for landscapes I recommend a shutter which allows the foreground to act longer than the rest upon the plate. Either the ferrous oxalate or the ordinary alkaline developer may be used. To intensify, I employ the two following baths:

First,

A.—Water	50 parts.
Bichloride of mercury	1 part.
Bromide of ammonium	1 "

afterwards,

B.—Water	50 parts.
Nitrate of silver	1 part.
Cyanide of potassium (pure)	1 "

This last may be replaced by a five per cent. solution of ammonia.

If, on the contrary, the negative requires to be reduced recourse may be had to a fresh bath of hyposulphite of soda, or a rapid immersion in a 1 per cent. bath of cyanide of potassium. When hyposulphite is used, it is desirable, after washing, to dip the plate for five minutes in

Water	100 parts.
Alum	10 "
Alcohol	1 part.

The tone of these plates is not the same as that of collodion negatives; it is as well to try them before printing. They permit of retouching.

Frilling does not generally take place, excepting in the hyposulphite; for that reason it is better to dip the plates in the alum bath before washing, or else to put alum in the hyposulphite bath.

* Read before the Photographic Society of France.

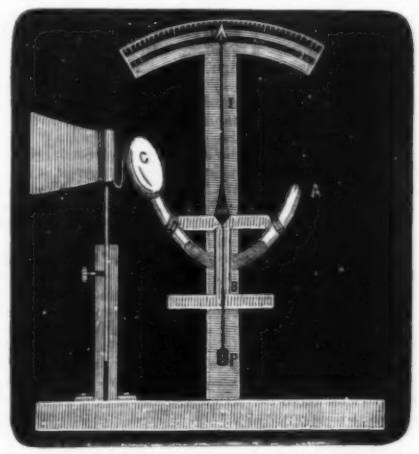
SYNTHESIS OF CITRIC ACID.

By E. Grimaux and P. Adam.

The authors prepared dichlorhydrin by means of glycerin and sulphur chloride, and oxidized it by means of potassium bichromate and sulphuric acid. The symmetric dichloracetone thus obtained was purified by combination with sodium bisulphite, and then heated in the water bath with concentrated hydrocyanic acid. The cyano-dichloracetone was treated with hydrochloric acid; the product distilled in a vacuum, and exhausted with ether. The dichloracetonic acid obtained was saturated with sodium carbonate, and heated with two mols. potassium cyanide in a concentrated solution. The liquid contains sodium dicyan-acetonate, which was saturated with gaseous hydrochloric acid, heated in the water bath for fifteen hours, and distilled in a vacuum. From the residue the citric acid was extracted by careful treatment with milk of lime.

DIFFERENTIAL THERMOMETER FOR CLASS DEMONSTRATION.

For the purposes of teaching, in a course of physics, the principal phenomena due to the radiation of heat there is usually employed a thermo-electrical pile and a galvanometer. If the latter is a reflecting apparatus, like that of Wiedemann, it is easily managed so that a large audience may see the most delicate thermic phenomena. The only inconvenience that these two apparatus present is their cost, and it is for this reason, perhaps, that studies of the radiation of heat are lightly passed over in some schools that have but little means at their disposal. To obviate this inconvenience, and to place the study of such phenomena within the reach of every one, Prof. Énrique Dufour has devised an apparatus which possesses the two merits of facility of construction and lowness of price. This apparatus, which we find figured and illustrated in the current number of the *Cronica Cientifica*, consists of a bent tube, A B (see accompanying cut), ending in a blackened bulb, C. The angle made by the two branches, A B, B C, may vary between 80 and 140 degrees. A horizontal cross piece, L L, of wood or metal, sustains the tube, and pivots on an axis resembling the blade of a balance. At the lower part of the axis a vertical piece carries a counterpoise, P, which serves to regulate the sensitiveness of the instrument. The bent tube contains a small column of mercury, four to five centimeters in height. To make the apparatus as regular as possible in its action there is introduced into the tube a small quantity of sulphuric acid along with the mercury to protect the surfaces of the latter from oxidation. When the air in the bulb dilates through the action of heat it displaces the mercury, and consequently causes the tilting of the tube, and the amount of the inclination is at once shown by the index hand, I, which passes over a graduated arc. If the apparatus be carefully constructed, the needle flies quickly back to its position of zero when the heat source is removed.



NEW DIFFERENTIAL THERMOMETER.

To apply this apparatus to the study of the phenomena of radiant heat, a brass cone polished on the inside is placed at a distance from the bulb; and the diathermic substances to be studied are arranged between the bulb and the small aperture in the cone. The flame of a candle suffices for the majority of experiments. The study of the absorbent and emittent powers of different substances is easily made by preparing a certain number of small copper disks (like those used in the voltaic pile), and covering one side with lampblack and the other side with the substance whose absorbent power it is desired to investigate. All these disks are heated together in a metallic vessel, and to study their emittent powers it is only necessary to place them successively before the bulb. If these same disks are all placed at an equal distance from any source of heat whatever, and their different faces are arranged so that the blackened side is turned toward the bulb while the other side is opposite the heat source, the inequality of their absorbent powers will be demonstrated by the unequal deviations of the apparatus.

As may be seen, this instrument is nothing else than a single-bulb differential thermometer, although its indications are much more easily seen from a distance than are those in the apparatus of Rumford or Leslie. It is hardly necessary to say that inasmuch as the instrument varies with the barometric pressure and the temperature of the surrounding atmosphere, the cross-piece, L L, should be made perfectly horizontal before beginning a series of experiments. This apparatus may be constructed of different dimensions. The one employed by Prof. Dufour has a cross-piece fourteen centimeters long, and the column of mercury is five centimeters in length. The apparatus may also be made with two bulbs, like the ordinary differential thermometer, but in this case it becomes less sensitive. With this instrument it is very easy to demonstrate the distribution of solar heat in space. With it, too, may be repeated the greater part of the experiments relative to the radiation of heat, with no other means than that of an ordinary candle. Doing away with the brass cone, the well known law that the intensity of heat received by any point is inversely proportional to the square of the distances that separates the point from the source of heat, may be verified with this thermometer just as with a photometer.

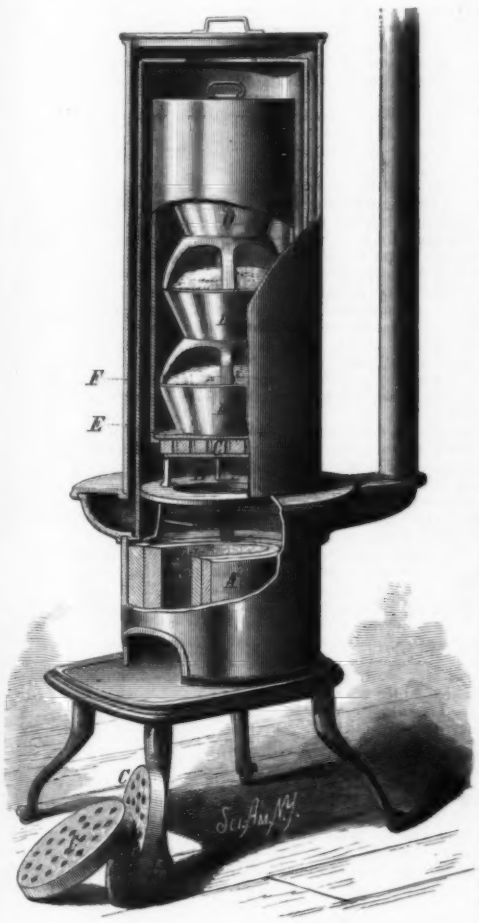
NEW PORTABLE OVEN.

IT is generally admitted that for some culinary operations the ordinary cook-stove and range are neither effective nor economical, and it has been determined by actual experiment that in the matter of baking, ordinary stoves are wasteful of both fuel and time.

The new portable oven shown in the engraving is designed to be used in connection with an ordinary portable furnace, and is not only capable of baking with a small amount of fuel, but it also prevents the dissemination of odors from the articles being cooked. The inventor contracts the fire pot of an ordinary portable furnace by inserting an extra lining, A, of fire brick; this serves the double purpose of materially reducing the fire space and of preventing the radiation of heat into the room—a very desirable feature in warm weather.

The top plate of the furnace has the usual opening for the reception of cooking vessels. To this opening is fitted a cylindrical casing, closed at the top by a removable cap, and to a flange surrounding the upper edge of the fire pot is fitted a cylinder concentric with the outer cylinder, forming between the two a flue, F. The inner cylinder has a central opening at the top, so that the products of combustion may pass upward in the inner cylinder, and downward in the flue, F, to the chimney flue.

An annular plate, B, and a plate, C, of refractory material are supported by legs which rest on the fire brick, A. The pans, D, which contain the dough, are supported one above another on the plate, C; the several pans are separated by light frames, and they are all inclosed by a cylindrical casing which rests upon the plate, C. By this arrangement the full effects of the fresh products of combustion is utilized in heating the inner casing and its contents, there being very little loss of heat by radiation, owing to the fact that the products of combustion, which pass upward around the inner casing, descending the flue, F, form an effectual air-jacket which prevents the chilling of the oven.



MACALPIN'S PORTABLE OVEN.

The design of the inventor is to concentrate and make use of all of the heat from the fire, so that none of it shall pass up the chimney and be wasted, and at the same time to have such control of it as to permit more or less of it to escape into the room as may be desired, and to carry off all offensive odors and smoke which commonly escape into the room when cooking is done in the usual way. Either coal or gas may be used as fuel. The oven is made in different sizes, large ones being made for hotels and bakeries.

The oven is raised from the furnace by cords or chains passing over pulleys in the ceiling, with counterbalance weights at the end.

These ovens may be adapted to broiling, frying, or cake making. We are informed by the inventor that a loaf of bread weighing two pounds two ounces has been baked in one of these ovens in thirty-two minutes, and that eight and a half pounds of bread can be baked in the same length of time.

This invention was recently patented by Mr. Daniel MacAlpin, 2041 Ridge avenue, Philadelphia, Pa., who should be addressed for further information.

ENAMEL FOR HOLLOW IRON WARE.

THE manufacture of enameled hollow ware has long been carried on in Silesia. The following are said to be the materials and processes employed in one of the larger establishments:

After being cleaned, the castings are pickled in dilute sulphuric acid and scrubbed with sand. They are then dipped into hot water and dried, when they are ready for the body, which is made as follows. Fifty parts of finely-ground dried quartz, 22·5 parts of crystallized borax, and 7·5 parts of fine fluorspar are sintered in a clay crucible, yielding 68·5 to 69 parts of a mass, which, after being carefully sorted to keep out impure pieces, is reduced to powder. Sixteen parts of this sintered mass are mixed with 6·5 to 12·5 parts of quartz, 4 to 6·5 parts of gray clay, and 0·5 part of borax. While this is being ground with water, 2·5 parts of clay, and 0·66 part of borax are added. After being brought to a proper consistency by the addition of water, this mixture is applied with a brush, dried, and burnt on, yielding a yellowish-brown sintered body, which adheres to iron firmly. The hollow ware is allowed to cool, and the material for the glaze is put on as a fine wash. This glaze is prepared by mixing 25 parts of fluorspar, 1 part of commercial oxide of zinc, 4·75 parts of oxide of zinc as obtained from calcining furnace of the establishment, 0·75 part of bone ash, and 0·03 to 0·05 part of smalt. The latter ingredient is added to counteract any yellowish tinge in the enamel. This mixture is looked upon as constituting the secret of the establishment, and it is specially prepared in the laboratory; 9 to 25 parts of it are mixed with 16 parts of feldspar, 9 to 9·75 parts of crystallized borax, 3·25 parts of crystallized soda, and 1·25 to 1·50 parts of saltpeter. The whole of it is put into a refractory crucible, having a hole in the bottom, through which the fused mass falls into a vessel placed below the grate. The cooled mass is finely ground with water, and to 30 parts of it 6 pieces of white clay, about 10 cubic inches in volume each, and 0·3 part of oxide of zinc are added. The mass thus prepared is applied with a brush, and after being dried, the goods are exposed to a heat sufficient to produce the enamel required.

HORSESHOE NAIL MAKING.

A GREAT deal of attention has of late years been paid to the manufacture of horseshoe nails by machinery, and though the first attempts were scarcely successful in competing with the hand-made nails as regards quality, still the subject has been so persistently followed up, that at the present day some machine-made nails may fairly be said to surpass the hand-made article both in quality and finish. One principal reason why the machine-made nails had such an uphill battle to fight was that some manufacturers, having succeeded in producing machinery which would work tolerably well, at once seemed to jump to the conclusion that inferior metal might be used. This arose, no doubt, from the fact that such manufacturers lacked a practical knowledge of what a horseshoe nail should be, and merely copied the shape of the hand-made nail, and thought their task completed. A horseshoe nail, though required of a certain stiffness for driving, should, nevertheless, be capable of being easily bent by the fingers. One thing that has been very much against the makers of machine-made nails has been the enormous expense of keeping the tools in repair, some of which are of no more thickness than the back of an ordinary table knife, though having to do heavy duty. It is also noticeable that the machine-made horsenail trade has almost entirely been usurped by the Americans. Keeping these points in view, Mr. H. P. Fenby, of the firm of Fenby & Fraser, of Leeds, has recently patented machinery of a novel type, which is now running at their works, and by which the evils mentioned above are avoided. In this process the bars are first rolled to a special section from billets of Siemens-Martin steel of Swedish make. These bars are then put into a pickling vat containing a solution which removes the scale caused by rolling, after which they are placed one at a time on a kind of small tramway feed, which continually urges the bar forward into a cutting-up machine, which is self-acting and continuous in its action. From this machine upwards of 100 nails per minute fall, the nails being delivered from the side of the machine into a box. By these means the entire bar is cut up automatically all but a short end, when the machine ceases cutting. The nails are then put into a special furnace, which keeps them at a blood red for a fixed time, when they are allowed to cool slowly, and are next put into a pickle, and afterward chemically treated, to thoroughly kill the action of the acid and cleanse them. They are now ready for the second machine operation, which consists in passing them through a special rolling machine, which by one operation gives a good square face and finish to the nail, and tempers it to a correct stiffness for driving without destroying the nature of the metal. The next and very important operation is pointing ready for driving. This is effected by a slight hammering action, which makes a sharp, clean point, without the burr often found on clipped points. The nails are now finished and ready for the market, being bright and pointed ready for driving.—*Ironmonger.*

ON THE TREATMENT OF FADED PRINTS FOR COPYING.

IT is by no means unusual to see on the professional cards and prospectuses of photographers, more particularly those practicing in the provinces, the following announcement: "Faded photographs restored, copied, enlarged, or reduced." But we imagine that many who make, or used to make, this announcement (for it is by no means so general now as it was formerly) would be somewhat perplexed to carry out that part of their prospectus relating to the *restoration* of faded photographs, when the photograph happened to be an ordinary silver print. The usual practice in such cases is to copy the print in its yellow or faded state, and afterward to work up the reproduction by hand, either in colors or monochrome. By this means very satisfactory results can be obtained; but in all instances when the picture is much faded there is great danger of the likeness (in the case of portraits) being lost unless it is skillfully manipulated by a competent artist.

Although there is no satisfactory method known by which a paper print that has actually faded can be *restored*, still there are means by which those that have passed into the "sere and yellow" stage may be so renovated that they can be reproduced of a quality but little inferior to what they would have yielded had they been copied when they were in their pristine vigor. The method, although an old one, is, we imagine, not so well known as it deserves to be, because it is but seldom resorted to by the copyist; hence our reason for directing attention to the subject. It simply consists in removing the yellowness of the picture by the action of bichloride of mercury in much the same manner that the tarnish of a daguerreotype is cleaned from the plate with cyanide of potassium. By this treatment the yellow tones of the prints quickly disappear, the whites regain much of their former purity, and the blacks become of a considerably warmer tone than they were originally. Although no detail is actually restored, still it appears to be because the yellowness that previously buried the lights and delicate half tints has been cleared away.

A picture that has been subjected to the action of a solution of bichloride of mercury will not possess the same range of tints from high lights to deep shadows that it did originally; for, although the whites will become nearly, or quite, as pure as they were at first, the shadows will not regain their original depth. But it will have a far greater range in its actinic qualities than when it was in its yellow condition, because we shall have white for the lights and a warm reddish-brown for the shadows; while before the treatment we had only yellow for the lights and certainly not a more non-actinic color for the shadows. Hence it will be seen that, notwithstanding the picture may not appear to be more vigorous visually, it is far more so chemically, and will consequently be much better adapted for copying as well as much improved in general appearance; for the color and vigor will correspond very nearly with the brown toned pictures at present so much in vogue.

There are two methods of treating prints with the bichloride of mercury. One is to remove the print from the mount and then to immerse it in a solution of the salt, which, if it be saturated, will remove the yellow tint, in most cases, in a few minutes. The print is then well washed to remove the bichloride, and after drying it is ready for remounting. Should the picture have been waxed, or, as it is more generally termed, "polished," with encaustic paste, it will be advisable to remove the wax with a little spirit of turpentine before soaking the print from its mount. The other method—which does not necessitate the removal of the print from the mount, which is sometimes an advantage—is the one originally published, now some twenty-five years ago, by Mr. R. F. Barnes, who was the first to suggest the employment of bichloride of mercury for restoring paper photographs. It is to place the print to be restored in contact with paper saturated with the mercurial salt.

In adopting this plan we have found that the most satisfactory results are obtained by damping several thicknesses of blotting paper with a weak solution of bichloride—about one part of a saturated solution diluted with three parts of water—and keeping it in contact with the print. This may be conveniently done by placing the print face upward on the glass of a pressure frame, then putting on the several thicknesses of the damp paper, on that a plate of glass, and screwing the whole up tight so that the paper is kept in close contact with the print and at the same time the moisture is prevented from evaporating. The time required by this method is much longer than in the previous one, frequently from six to twenty-four hours being requisite, according to the amount of yellowness to be removed. When the picture is sufficiently whitened the bichloride should be eliminated by gently sponging it several times with water, and blotting off each time with bibulous paper.

Although we have mentioned a saturated solution in the first method we should advise a dilute one to be employed, as then the action appears to be more even and regular, especially (and this is frequently the case with old prints) as the surface is very repellent of aqueous solutions. We have noticed but little difference between the action of the mercurial salt on prints that have been toned with the alkaline gold bath and those by the old hypo and gold toning and fixing bath, in which the toning action was probably as much due to sulphur as to gold—except, perhaps, that with the gold toned prints the action is a little quicker and the resulting picture somewhat less vigorous; but it is quite possible that this difference may be more due to the sulphur toned prints having been made from much stronger negatives than were the gold toned ones. However, with each the plan appears to be equally efficacious.

With regard to the future permanence of prints that have been subjected to the mercurial treatment, we may mention that we have some by us that were operated upon some years since which appear to have undergone no further change. The whites remain clear, and the shadows apparently unchanged; but how far such pictures may be considered permanent in the true sense of the term, we are scarcely in a position to hazard an opinion.—*Br. Jour. of Photography.*

THE REVERSED ACTION OF LIGHT IN SOLAR PHOTOGRAPHY.

By J. JANSSEN.

I HAVE been able to extend and complete, by a compendious study, the results which I had the honor of communicating to the Photographic Society of France at its last meeting.

At the point at which I have now arrived I have been enabled to ascertain that the action of light alone—whether, on the one hand, that action be prolonged, or, on the other, its intensity be increased in suitable proportion—I have ascertained, I say, that this action alone, and without the aid of any accessory reaction, produces on the photographic plate a succession of the six following conditions:

1. A negative image (the ordinary image).
2. A first neutral state, in which the plate becomes uniformly obscure under the action of the developer.
3. A positive image, which succeeds the first neutral state.*
4. A second neutral state, opposed to the first in so far as that the plate becomes uniformly clear under the action of the developer.
5. A new negative image, which succeeds the second neutral state. This image is similar to the first negative image, but differs from it both by the intermediate conditions which separate the two and by the enormous difference of luminous intensity necessary to produce it. The negative image of the second order demands, in fact, for its production a luminous intensity of more than a million times that which produces the negative image of the first order.
6. A second darkened state, in which the plate becomes uniformly obscure under the action of the developer.

Such is the succession of the phenomena which the dry plate may present when submitted to the prolonged action of light. It is only the use of our instruments of solar photography that enables us to realize the enormous variations of luminous power by which these results have been obtained. The plates experimented upon have been principally gelatine, tannin, washed collodion emulsion, etc., etc.

I have obtained, notably, plates showing the succession of the different states—the negative, positive, and the negative of the second order—both for sun pictures and for landscapes; some plates in which the sun is seen in positive in

* This positive image has recently been recognized in Germany.

the midst of a negative, cloudy, sky; others in which the sun is negative in a positive telluric halo in a negative cloudy sky, etc.

As I said at the last meeting of the society, it seems as if these new results might be usefully applied in obtaining photographs of the solar chromosphere. There is no doubt that they throw great light on the theory of photographic phenomena.

I hope at a future meeting to lay before the society more details of these experiments, and to show specimens of the results I mentioned. The sole object of this communication is to describe the results already obtained.

GEOLOGY.

The annual meeting of the British Association for the Advancement of Science took place at Swansea, August 25, 1880. The first paper was the following inaugural address of the President, Andrew Crombie Ramsay, LL.D., F.R.S., V.P.G.S., Director General of the Geological Survey of the United Kingdom, and of the Musuem of Practical Geology:

ON THE RECURRENCE OF CERTAIN PHENOMENA IN GEOLOGICAL TIME.

In this address I propose to consider the recurrence of the same kind of incidents throughout all geological time, as exhibited in the various formations and groups of formations that now form the known parts of the external crust of the earth. This kind of investigation has for many years forced itself on my attention, and the method I adopt has not heretofore been attempted in all its branches. In older times, Hutton and Playfair, in a broad and general manner, clearly pointed the way to the doctrine of uniformity of action and results, throughout all known geological epochs down to the present day; but after a time, like the prophets of old, they obtained but slight attention and were almost forgotten, and the wilder cosmical theories of Werner more generally ruled the opinions of the geologists of the time. Later still, Lyell followed in the steps of Playfair, with all the advantages that the discoveries of William Smith afforded, and aided by the labors of that band of distinguished geologists, Sedgwick, Buckland, Mantell, De la Beche, Murchison, and others, all of whom some of us knew. Notwithstanding this new light, even now there still linger the relics of the belief (which some of these geologists also maintained) that the physical phenomena which produced the older strata were not only different in kind, but also in degree, from those which now rule the external world. Oceans, the waters of which attained a high temperature, attended the formation of the *primitive* crystalline rocks. Volcanic eruptions, with which those of modern times are comparatively insignificant, the sudden upheaval of great mountain chains, the far more rapid decomposition and degradation of rocks, and, as a consequence, the more rapid deposition of strata formed from their waste—all these were assumed as certainties, and still linger in some parts of the world among living geologists of deservedly high reputation. The chief object of this address is, therefore, to attempt to show that, whatever may have been the state of the world long before geological history began, as now written in the rocks, all known formations are comparatively so recent in geological time, that there is no reason to believe that they were produced under physical circumstances differing either in kind or degree from those with which we are now more or less familiar.

It is unnecessary for my present purpose to enter into details connected with the recurrence of marine formations, since all geologists know that the greater part of the stratified rocks were deposited in the sea, as proved by the mollusks and other fossils which they contain; and the order of their deposition and the occasional stratigraphical breaks in succession are also familiar subjects. What I have partly to deal with now are exceptions to true marine stratified formations, and after some other important questions have been considered, I shall proceed to discuss the origin of various non-marine deposits from nearly the earliest known time down to what by comparison may almost be termed the present day.

METAMORPHISM.

All, or nearly all, stratified formations have been in a sense metamorphosed, since, excepting certain limestones, the fact of loose incoherent sediments having been by pressure and other agencies turned into solid rocks constitutes a kind of metamorphism. This, however, is only a first step toward the kind of metamorphism, the frequent recurrence of which in geological time I have now to insist upon, and which implies that consolidated strata have undergone subsequent changes of a kind much more remarkable.

Common stratified rocks chiefly consist of marls, shales, slates, sandstones, conglomerates, and limestones; generally distinct and definite; but not infrequently a stratum, or strata, may partake of the characters in varied proportions, of two or more of the above-named species. It is from such strata that metamorphic rocks have been produced, exclusive of the metamorphism of igneous rocks, on which I will not enter. These may be looked for in every manual of geology, and usually they may be found in them.

As a general rule, metamorphic rocks are apt to be much contorted, not only on a large scale, but also that the individual layers of mica quartz and feldspar in gneiss are bent and folded in a great number of minute convolutions, so small that they may be counted by the hundred in a foot or two of rock. Such metamorphic rocks are often associated with masses of granite both in bosses and in interstratified beds or layers, and where the metamorphism becomes extreme it is often impossible to draw a boundary line between the gneiss and the granite; while, on the other hand, it is often impossible to draw any true boundary between gneiss (or other metamorphic rocks) and the ordinary strata that have undergone metamorphism. Under these circumstances it is not surprising that when chemically analyzed, there is often little difference in the constituents of the unmetamorphosed and the metamorphosed rock. This is a point of some importance in relation to the origin and non-primitive character of gneiss and other varieties of foliated strata, and also of some quartzites and crystalline limestones.

I am aware that in North America formations consisting of metamorphic rocks have been stated to exist of older date than the Laurentian gneiss, and under any circumstances it is obvious that vast tracts of pre-Laurentian land must have existed in all regions, by the degradation of which sediments were derived wherewith to provide materials for the deposition of the originally unaltered Laurentian strata. In England, Wales, and Scotland attempts have also been made to prove the presence of more ancient formations, but I do not consider the data provided sufficient to warrant any such conclusion. In the Highlands of Scotland, and in some of the Western Isles, there are gneissic rocks of pre-Cambrian age, which, since they were first described by Sir Roderick Murchison in the Northwest Highlands, have been, I think, justly considered to belong to the Laurentian series, unconformably underlying Cambrian and Lower Silurian rocks, and as yet there are no sufficient grounds for dissenting from his conclusion that they form the oldest known rocks in the British Islands.

It is unnecessary here to discuss the theory of the causes that produced the metamorphism of stratified rocks, and it may be sufficient to say, that under the influence of deep underground heat, aided by moisture, sandstones have been converted into quartzites, limestones have become crystalline, and in shaly, slaty, and schistose rocks, under like circumstances, there is little or no development of new material, but rather, in the main, a rearrangement of constituents according to their chemical affinities in rudely crystalline layers, which have very often been more or less developed in pre-existing planes of bedding. The materials of the whole are approximately the same as those of the unaltered rock, but have been rearranged in layers, for example, of quartz, feldspar, and mica, or of hornblende, etc., while other minerals, such as schorl and garnets, are of not infrequent occurrence.

It has for years been an established fact that nearly the whole of the mountain masses of the Highlands of Scotland (exclusive of the Laurentian, Cambrian, and Old Red Sandstone formations), mostly consist of gneissic rocks of many varieties, and of quartzites, and a few bands of crystalline limestone, which, from the north shore to the edge of the Old Red Sandstone, are repeated again and again in stratigraphical convolutions great and small. Many large bosses, veins, and dikes of granite are associated with these rocks, and, as already stated, it sometimes happens that it is hard to draw a geological line between granite and gneiss and *vice versa*. These rocks, once called Primary or Primitive, were first proved by Sir Roderick Murchison to be of Lower Silurian age, thus revolutionizing the geology of nearly one-half of Scotland. To the same age belongs by far the greater part of the broad hilly region of the south of Scotland that lies between St. Abb's Head on the east and the coast of Ayrshire and Wigtonshire on the west. In the southwest part of this district several great masses of granite rise amid the Lower Silurian rocks, which in their neighborhood pass into mica-schist and even into fine-grained gneiss.

In Cornwall the occurrence of Silurian rocks is now well known. They are of metamorphic character, and partly associated with granite; and at Start Point, in South Devonshire, the Silurian strata have been metamorphosed into quartzites.

In parts of the Cambrian areas, Silurian rocks in contact with granite have been changed into crystalline hornblendic gneiss, and in Anglesey there are large tracts of presumed Cambrian strata, great part of which have been metamorphosed into chlorite and mica-schist and gneiss, and the same is partly the case with the Lower Silurian rocks of the center of the island, where it is almost impossible to disentangle them from the associated granite.

In Ireland similar metamorphic rocks are common, and, on the authority of Prof. Hull, who knows them well, the following statements are founded: "Metamorphism in Ireland has been geographical and not stratigraphical, and seems to have ceased before the Upper Silurian period.

"The epoch of greatest metamorphism appears to have been that which intervened between the close of the Lower Silurian period and the commencement of the Upper Silurian, taking the formations in ascending order.

"It is as yet undecided whether Laurentian rocks occur in Ireland. There are rocks in northwest Mayo very like those in Sutherlandshire, but if they are of Laurentian age they come directly under the metamorphosed Lower Silurian rocks, and it may be very difficult to separate them.

"Cambrian purple and green grits are not metamorphosed in the counties of Wicklow and Dublin, but the same beds at the southern extremity of County Wexford, near Carnsore Point, have been metamorphosed into mica-schist and gneiss.

"In the east of Ireland the Lower Silurian grits and slates have not been metamorphosed, except where in proximity to granite, into which they insensibly pass in the counties of Wicklow, Dublin, Westmeath, Cavan, Longford, and Down; but in the west and northwest of Ireland they have metamorphosed into several varieties of schists, hornblende-rock, *and gneiss, or foliated granite.*"

It would be easy to multiply cases of the metamorphism of Silurian rocks on the continent of Europe, as, for example, in Scandinavia and in the Ural Mountains, where, according to Murchison, "by following its masses upon their strike, we are assured that the same zone which in one tract has a mechanical aspect and is fossiliferous, graduates in another parallel of latitude into a metamorphic crystalline condition, whereby not only the organic remains, but even the original impress of sedimentary origin, are to a great degree obliterated." The same kind of phenomena are common in Canada and the United States; and Medlicott and Blanford, in "The Geology of India," have described the thorough metamorphism of Lower Silurian strata into gneiss and syenitic and hornblende schists.

In Britain, none of the Upper Silurian rocks have undergone any serious change beyond that of ordinary consolidation, but in the Eastern Alps, at Gratz, Sir Roderick Murchison has described both Upper Silurian and Devonian strata interstratified with separate courses of metamorphic chloritic schist.

Enough has now been said to prove the frequent occurrence of metamorphic action among Cambrian and Lower and Upper Silurian strata.

If we now turn to the Devonian and Old Red Sandstone strata of England and Scotland, we find that metamorphic action has also been at work, but in a much smaller degree. In Cornwall and Devon, five great bosses of granite stand out amid the stratified Silurian, Devonian, and Carboniferous formations. Adjoining or near these bosses the late Sir Henry De la Beche remarks that "in numerous localities we find the coarser slates converted into rocks resembling mica-slate and gneiss, a fact particularly well exhibited in the neighborhood of Meavy, in the southeast of Tavistock," and "near Camelford we observed a fine arenaceous and micaceous grauwacke turned into a rock resembling mica-slate near the granite." Other cases are given by the same author of slaty strata turned into mica-schist and gneiss in rocks now generally considered to be of Devonian age.

The Devonian rocks and Old Red Sandstone are of the same geological age, though they were deposited under different conditions, the first being of marine, and the latter of fresh-water origin. The Old Red Sandstone of Wales, England, and Scotland has not, as far as I know, suffered any metamorphism, excepting in one case in the northeast of Ayrshire, near the sources of the Avon Water, where a large boss of granite rises through the sandstone, which all round has been rendered crystalline with well-developed crystals of feldspar.

On the Continent of Europe, a broad area of Devonian strata lies on both banks of the Rhine and the Moselle. Forty years ago, Sedgwick and Murchison described the crystalline quartzites, chlorite, and micaceous slates of the Hundsruck and the Taunus, and from personal observation I know that the rocks in the country on either side of the Moselle are, in places, of a foliated or semi-foliated metamorphic character. In the Alps also, as already noticed, metamorphic Devonian strata occur interstratified with beds of metamorphic schists, and Sir Roderick adds, "we have ample data to affirm that large portions of the Eastern Alps . . . are occupied by rocks of true paleozoic age, which in many parts have passed into a crystalline state."

I know of no case in Britain where the Carboniferous strata have been thoroughly metamorphosed, excepting that in South Wales, beds of coal, in the west of Caermarthenshire and in South Pembrokeshire, gradually pass from so-called bituminous coal into anthracite. The same is the case in the United States, in both instances the Carboniferous strata being exceedingly disturbed and contorted. In the Alps, however, Sir Roderick Murchison seems to have believed that Carboniferous rocks may have been metamorphosed; a circumstance since undoubtedly proved by the occurrence of a coal-measure calamite, well preserved, but otherwise partaking of the thoroughly crystalline character of the gneiss in which it is embedded, and which was shown to me by the late Prof. Gastaldi, at Turin.

I am well acquainted with all the Permian strata of the British Islands and of various parts of continental Europe, and nowhere, that I have seen, have they suffered from metamorphic action, and strata of this age are, I believe, as yet unknown in the Alps. This closes the list of metamorphism of paleozoic strata.

I will not attempt (they are so numerous) to mention all the regions of the world in which Mesozoic or Secondary formations have undergone metamorphic action. In Britain and the non-mountainous parts of France, they are generally quite unaltered, but in the Alps it is different. There, as every one knows who is familiar with that region, the crystalline rocks in the middle of the chain have the same general strike as the various flanking stratified formations. As expressed by Murchison, "as we follow the chain from N.E. to S.W. we pass from the clearest types of sedimentary rocks, and, at length, in the Savoy Alps, are immersed in the highly altered mountains of Secondary limestone," while "the metamorphism of the rocks is greatest as we approach the center of the chain," and, indeed, any one familiar with the Alps of Switzerland and Savoy knows that a process of metamorphism has been undergone *by all the Jurassic rocks* (Lias and Oolites) of the great mountain chain. Whether or not any strata of Neocomian and Cretaceous age have been well metamorphosed in this region I am unable to say; but it seems to be certain that the Eocene or Lower Tertiary Alpine formation, known as the Flysch, contains beds of black schists which pass into Lydian stone, and also that in the Grisons it has been converted into gneiss and mica-schist, a fact mentioned by Studer and Murchison. I also have seen in the country north of the Oldenhorn, Nummulitic rocks so far foliated that they formed an imperfect gneiss.

In Tierra del Fuego, as described by Darwin, clay slates of early cretaceous date pass into gneiss and mica-slate with garnets, and in Chonos Islands, and all along the great Cordillera of the Andes of Chili, rocks of Cretaceous or Cretaceo-oolitic age have been metamorphosed into foliated mica-slate and gneiss, accompanied by the presence of granite, syenite, and greenstone.

This ends my list, for I have never seen, or heard, of metamorphic rocks of later date than those that belong to the Eocene series. Enough, however, has been said to prove that from the Laurentian epoch onward, the phenomenon of extreme metamorphism of strata has been of frequent recurrence all through Paleozoic and Mesozoic times, and extends even to a part of the Eocene series equivalent to the soft unaltered strata of the formations of the London and Paris basins, which, excepting for their fossil contents and sometimes highly inclined positions, look as if they had only been recently deposited.

VOLCANOES.

The oldest volcanic products of which I have personal knowledge are of Lower Silurian age. These in Wales consist of two distinct series, the oldest of which, chiefly formed of feldspathic lavas and volcanic ashes, lie in and near the base of the Llandeilo beds, and the second, after a long interval of repose, were ejected and intermingled with the strata forming the middle part of the Bala beds. The Lower Silurian rocks of Montgomeryshire, Shropshire, Radnorshire, Pembrokeshire, Cumberland, and Westmoreland, are to a great extent also the result of volcanic eruptions, and the same kind of volcanic rocks occur in the Lower Silurian strata of Ireland. I know of no true volcanic rocks in the Upper Silurian series.

In the Old Red Sandstone of Scotland lavas and volcanic ashes are of frequent occurrence, interstratified with the ordinary lacustrine sedimentary strata. Volcanic rocks are also intercalated among the Devonian strata of Devonshire. I know of none in America or on the Continent of Europe.

In Scotland volcanic products are common throughout nearly the whole of the Carboniferous sub-formations, and they are found also associated with Permian strata.

I now come to the Mesozoic or Secondary epochs. Of Jurassic age (Lias and Oolites), it is stated by Lyell with some doubt, that true volcanic products occur in the Morea and also in the Apennines, and it seems probable, as stated by Medlicott and Blanford, that the Rajmahal traps may also be of Jurassic age.

In the Cordillera of South America, Darwin has described a great series of volcanic rocks intercalated among the Cretaceo-oolitic strata that forms so much of the chain; and the same author in his "Geological Observations in South America," states that the Cordillera has been, probably with some quiescent periods, a source of volcanic matter from an epoch anterior to our Cretaceo-oolitic formation to the present day. In the Deccan volcanic traps rest on Cretaceous beds, and are overlaid by Nummulitic strata, and according to Medlicott and Blanford, these were poured out in the interval between Middle Cretaceous and Lower Eocene times.

In England the only instance I know of a volcano of Eocene age is that of Monte Bolca, near Verona, where the volcanic products are associated with the fissile limestone of that area.

The well preserved relics of Miocene volcanoes are prevalent over many parts of Europe, such as Auvergne and The Velay, where the volcanic action began in Lower Miocene times, and was continued into the Pliocene epoch. The volcanoes of the Eifel are also of the same general age, together with the ancient Miocene volcanoes of Hungary.

The volcanic rocks of the Azores, Canaries, and Madeira are of Miocene age, while in Tuscany there are extinct volcanoes that began in late Miocene, and lasted into times contemporaneous with the English Coralline Crag. In the north of Spain also, at Olot, in Catalonia, there are perfect craters and cones remaining of volcanoes that began to act in newer Pliocene times and continued in action to a later geological date. To these I must add the great *coulées* of Miocene lava, so well known in the Inner Hebrides, on the mainland, near Oban, etc., in Antrim in the north of Ireland, in the Faroe Islands, Greenland, and Franz-Joseph Land. It is needless, and would be tiresome, further to multiply instances, for enough has been said to show that in nearly all geological ages volcanoes have played an important part, now in one region, now in another, from very early Paleozoic times down to the present day; and, as far as my knowledge extends, at no period of geological history is there any sign of their having played a more important part than they do in the epoch in which we live.

MOUNTAIN CHAINS.

The mountain chains of the world are of different geological ages, some of them of great antiquity, and some of them comparatively modern.

It is well known that in North America the Lower Silurian rocks lie unconformably on the Laurentian strata, and also that the latter had undergone a thorough metamorphism and been thrown into great anticlinal and synclinal folds, accompanied by intense minor convolutions, before the deposition of the oldest Silurian formation, that of the Potsdam Sandstone. Disturbances of the nature alluded to imply beyond a doubt that the Laurentian rocks formed a high mountain chain of pre-Silurian date, which has since constantly been worn away and degraded by sub-aerial denudation.

In Shropshire, and in parts of North Wales, and in Cumberland and Westmoreland, the Lower Silurian rocks by upheaval formed hilly land before the beginning of the Upper Silurian epoch; and it is probable that the Lower Silurian gneiss of Scotland formed mountains at the same time, probably very much higher than now. However that may be, it is certain that these mountains formed high land before and during the deposition of the old Red Sandstone, and the upheaval of the great Scandinavian chain (of which the Highlands may be said to form an outlying portion) also preceded the deposition of the Old Red strata. In both of these mountain regions the rocks have since undergone considerable movements, which in the main seem to have been movements of elevation, accompanied undoubtedly by that constant atmospheric degradation to which all high land is especially subject.

The next great European chai in point of age is that of the Ural, which according to Murchison is of pre-Permian age, a fact proved by the Permian conglomerates which were formed from the waste of the older strata. On these they lie quite unconformably and nearly undisturbed on the western flank of the mountains.

In North America the great chain of the Alleghany Mountains underwent several disturbances, the last (a great one) having taken place after the deposition of the Carboniferous rocks, and before that of the New Red Sandstone. The vast mountainous region included under the name of the Rocky Mountains, after several successive disturbances of upheaval, did not attain its present development till after the Miocene or Middle Tertiary epoch.

In South America, notwithstanding many oscillations of level recorded by Darwin, the main great disturbance of the strata that form the chain of the Andes took place apparently in *post-cretaceous times*.

The Alps, the rudiments of which began in more ancient times, received their greatest disturbance and upheaval in post-Eocene days, and were again raised at least 5,000 feet (I believe much more) at the close of the Miocene epoch. The Apennines, the Pyrenees, the Carpathians, and the great mountain region on the east of the Adriatic and southward into Greece, are of the same general age, and this is also the case in regard to the Atlas in North Africa and the Caucasus on the borders of Europe and Asia. In the north of India the history of the Great Himalayan range closely coincides with that of the Alps, for while the most powerful known disturbance and elevation of the range took place after the close of the Eocene epoch, a subsequent elevation occurred in post-Miocene times closely resembling and at least equal to that sustained by the Alps at the same period.

It would probably not be difficult by help of extra research to add other cases to this notice of recurrences of the upheaval and origin of special mountain chains, some of which I have spoken of from personal knowledge; but enough has been given to show the bearing of this question on the argument I have in view, namely, that of repetition of the same kind of events throughout all known geological time.

SALT AND SALT LAKES.

I now come to the discussion of the circumstances that produced numerous recurrences of the development of beds of various salts (chiefly common rock salt) in many formations, which it will be seen are to a great extent connected with continental or inland conditions. In comparatively rainless countries salts are often deposited on the surface of the ground by the effect of solar evaporation of moisture from the soil. Water dissolves certain salts in combination with the ingredients of the underlying rocks and soils, and brings it to the surface, and when solar evaporation ensues the salt or salts are deposited on the ground. This is well known to be the case in and near the region of the Great Salt Lake in North America, and in South America, in some of the nearly rainless districts of the Cordillera, extensive surface deposits of salts of various kinds are common. The surface of the ground around the Dead Sea is also in extra dry seasons covered with salt, the result of evaporation, and in the upper provinces of India (mentioned by Medlicott and Blanford) "many tracts of land in the Indo-Gangetic alluvial plain are rendered worthless for cultivation by an efflorescence of salt known in the North-West Provinces as *Reh*;" while every geographer knows that in Central Asia, from the western shore of the Caspian Sea to the Kinshan Mountains of Mongolia, with rare exceptions nearly every lake is salt in an area at least 3,500 miles in length. This circumstance is due to the fact that all so-called fresh water springs, and therefore all rivers, contain small quantities of salt in solution only appreciable to the chemist, and by the constant evaporation of pure water from the lakes, in the course of time it necessarily happens that these salts get concentrated in the water by the effect of solar heat, and, if not already begun, precipitation of solid salts must ensue.

The earliest deposits of rock salt that I know about have been described by Mr. A. B. Wynne, of the Geological Survey of India, in his memoir "On the Geology of the Salt Range in the Punjab."* The beds of salt are of great thickness, and along with gypsum and dolomitic layers occur in marl of a *red color* like our Keuper Marl. This color I have for many years considered to be, in certain cases, apt to indicate deposition of sediments in inland lakes, salt or fresh, as the case may be; and with respect to these strata in the Punjab Salt Range, authors seem to be in doubt whether they were formed in inland lakes or in lagoons near the seaboard, which at intervals were liable to be flooded by the sea, and in which in the hot seasons salts were deposited by evaporation caused by solar heat. For my argument it matters but little which of these was the true physical condition of the land at the time, though I incline to think the inland lake theory most probable. The age of the strata associated with this salt is not yet certainly ascertained. In "The Geology of India," Medlicott and Blanford incline to consider them of Lower Silurian age, and Mr. Wynne, in his "Geology of the Salt Range," places the salt and gypsum beds doubtfully on the same geological horizon.

The next salt bearing formation that I shall notice is the Salina or Onondaga Salt Group of North America, which forms part of the Upper Silurian rocks, and lies immediately above the Niagara Limestone. It is rich in gypsum and in salt brine, often of a very concentrated character, "which can only be derived from original depositions of salt," and it is also supposed by Dr. T. Sterry Hunt to contain solid rock salt 115 feet in thickness at the depth of 2,085 feet, near Saginaw Bay, in Michigan.

In the Lower Devonian strata of Russia, near Lake Ilmen, Sir R. Murchison describes salt springs at Starai Russa. Sinkings "made in the hope of penetrating to the source of these salt springs" reached a depth of 600 feet without the discovery of rock salt, "and we are left in doubt whether the real source of the salt is in the lowest beds of the Devonian rocks or even in the Silurian system."

In the United States brine springs also occur in Ohio, Pennsylvania, and Virginia, in Devonian rocks.

In Michigan salts are found from the Carboniferous down to the Devonian series; and in other parts of the United States, Western Pennsylvania, Virginia, Ohio, Illinois, and Kentucky, from the lower Coal-measures salts are derived which must have been deposited in inland areas, since even in the depths of inland seas that communicate with the great ocean, such as the Mediterranean and the Red Sea, no great beds of salt can be deposited. Before such strata of salt can be formed supersaturation must have taken place.

In the North of England, at and near Middlesborough, two deep bore holes were made some years ago in the hope of reaching the Coal-measures of the Durham coalfield. One of them at Salthome was sunk to a depth of 1,355 feet. First they passed through 74 feet of superficial clay and gravel, next through about 1,175 feet of red sandstones and marls, with beds of rock salt and gypsum. The whole of these strata (excepting the clay and gravel) evidently belong to the Keuper marls and sandstones of the upper part of our New Red series. Beneath these they passed through 67 feet of dolomitic limestone, which in this neighborhood forms the upper part of the Permian series, and beneath the limestone the strata consist of 27 feet of gypsum and rock salt and marls, one of the beds of rock salt having a thickness of 14 feet. This bed of Permian salt is of some importance, since I have been convinced for long that the British Permian strata were deposited, not in the sea, but in salt lakes comparable in some respects to the Great Salt Lake in Utah, and in its restricted fauna to the far greater salt lake of the Caspian Sea. The gypsum, the dolomite or magnesian limestone, the red marls covered with rain pittings, the sun cracks, and the impressions of footprints of reptiles made in the soft sandy marls when the water was temporarily lowered by the solar evaporation of successive summers, all point to the fact that our Permian strata were not deposited in the sea, but in a salt lake or lakes once for a time connected with the sea. The same may be said of other Permian areas in the central parts of the Continent of Europe, such as Stassfurth and Anhalt, Halle and Altern, in Thuringia, and Sperenberg, near Berlin, and also in India.†

Neither do I think that the Permian strata of Russia, as described by Sir Roderick Murchison, were necessarily, as he implies, deposited in a wide ocean. According to his view all marine life universally declined to a minimum after the close of the Carboniferous period, that decline beginning with the Permian and ending with the Triassic epochs. Those who believe in the doctrine of evolution will find it hard to accept the idea which this implies, namely, that all the prolific forms of the Jurassic series sprang from the scanty faunas of the Permian and Triassic epochs. On the contrary, it seems to me more rational to attribute the poverty of the faunas of these epochs to accidental abnormal conditions in certain areas that for a time partially disappeared during the deposition of the continental Muschelkalk which is absent in the British Triassic series.

In the whole of the Russian Permian strata only fifty-three species were known at the time of the publication of "Russia and the Ural Mountains," and I have not heard that this scanty list has been subsequently increased. I am, therefore, inclined to believe that the red marls, grits, sandstones, conglomerates, and great masses of gypsum and rock-salt were all formed in a flat inland area which was occasionally liable to be invaded by the sea during intermittent intervals of minor depression, sometimes in one area, sometimes in another, and the fauna small in size and poor in numbers is one of the results, while the deposition of beds of salt and gypsum is another. If so, then, in the area now called Russia, in sheets of inland Permian water, deposits were formed strictly analogous to those of Central Europe and of Britain, but on a larger scale.

Other deposits of salt deep beneath overlying younger strata are stated to occur at Bromberg, in Prussia, and many more might be named as lying in the same formation in Northern Germany.

If we now turn to the Triassic series it is known that it consists of only two chief members in Britain, the Bunter Sandstones and the Keuper or New Red Marls, the Muschelkalk of the Continent being absent in our islands. No salt is found in the Bunter sandstones of England, but it occurs in these strata at Schöningen, in Brunswick, and also near Hanover. In the lower part of the Keuper series deposits of rock-salt are common in England and in Ireland. At Almersleben, near Calbe, rock-salt is found in the Muschelkalk, and also at Erfurt and Slottenheim, in Thuringia, and at Wilhelmsglück, in Wurtemberg. In other Triassic areas it is known at Honigsen, in Hanover, in middle Keuper beds. In the red shales at Sperenberg and Leith on the Lower Elbe, salt was found at the depth of 3,000 feet, and at Stassfurth the salt is said to be "several hundred yards thick."

In central Spain rock-salt is known, and at Tarragona, Taen, and also at Santander, in the north of Spain, all in Triassic strata. Other localities may be named in the Upper Trias, such as the Salzkammergut, Aussee, Hallstatt, Ischl, Hallein in Salzburg, Halle in the Tyrol, and Berchesgaden in Bavaria.

In the Salt Range of mountains in Northern India salliferous strata are referred with some doubt by Medlicott and Blanford to the Triassic strata.

In the Jurassic series (Lias and Oolites) salt and gypsum are not uncommon. One well-known instance occurs at Berg, in the valley of the Rhone, in Switzerland, where salt is derived from the Lias. Salt and gypsum are also found in Jurassic rocks at Burgos, in Spain. At Gap, in France, there is gypsum, and salt is found in the Austrian Alps in Oolitic limestone.

In the Cretaceous rocks salt occurs, according to Lartet, at Jebel Usdom by the Red Sea, and other authorities state that it occurs in the Pyrenees and at Biskra, in Africa, where "mountains of salt" are mentioned as of Cretaceous age. The two last-named localities are possibly uncertain; but whether or not this is the case, it is not the less certain that salt has been deposited in Cretaceous rocks, and, judging by analogy, probably in inland areas of that epoch.

In the Eocene or Older Tertiary formations, rock-salt is found at Cardona, in Spain, and at Kohat, in the Punjab, it occurs at the base of Nummulitic beds. It is also known at Mandi, in India, in strata supposed to be of Nummulitic Eocene age.

The record does not end here, for a zone of rock-salt lies in Sicily at the top of the Salina clays in Lower Miocene beds, and in Miocene strata gypsum is found at several places in Spain, while salt also occurs in beds that are doubtfully of Miocene age (but may be later) at Wielitzka in Poland, Kalusz in Galicia, Bukowina, and also in Transylvania.

In Pliocene or Later Tertiary formation, thick beds of gypsum are known in Zante, and strata of salt occur in Roumania and Galicia, while in Pliocene rocks, according to Dana, or in post-Tertiary beds, according to others, a thick bed of pure salt was penetrated at a depth of 38 feet at Petit Anse, in Louisiana. This ends my list, though I have no doubt that, by further research, many more localities might be given. Enough, however, has been done to show that rock-salt (and other salts) are of frequent *recurrence* throughout all geological time, and as in my opinion it is impossible that common salt can be deposited in the open ocean, it follows that this and other salts must have been precipitated from solutions, which, by the effect of solar evaporation, became at length supersaturated, like those of the Dead Sea, the Great Salt Lake of Utah, and in other places which it is superfluous to name.

FRESH WATER.—LAKES AND ESTUARIES.

I now come to the subject of recurrences of fresh water conditions both in lakes and estuaries. In the introduction to the "Geology of India," by Messrs. Medlicott and Blanford, mention is made of the Blaini and Krol rocks as probably occupying "hollows formed by denudation in the old gneissic rocks," and the inference is drawn that "if this be a correct view, it is probable that the cis Himalayan paleozoic rocks are in great part of fresh-water origin, and that the present crystalline axis of the Western Himalayas approximately coincides with the shore of the ancient paleozoic continent, of which the Indian peninsula formed a portion." The Krol rocks are classed broadly with "Permian and Carboniferous" deposits, but the Blaini beds are doubtfully considered to belong to Upper Silurian strata. If this point be by and by established, this is the earliest known occurrence of fresh-water strata in any of the more ancient paleozoic formations.

It is a fact worthy of notice that the color of the strata formed in old lakes (whether fresh or salt) of paleozoic and mesozoic age is apt to be red: a circumstance due to the fact that each little grain of sand or mud is usually coated with a very thin pellicle of peroxide of iron. Whether or not the red and purple Cambrian rocks* may not be *partly* of fresh-water origin, is a question that I think no one but myself has raised.†

There is, however, in my opinion, no doubt with regard to the fresh-water origin of the Old Red Sandstone, as distinct from the contemporaneous marine deposits of the Devonian strata. This idea was first started by that distinguished geologist, Doctor Fleming, of Edinburgh, followed by Mr. Godwin-Austen, who, from the absence of marine shells and the nature of the fossil fishes in these strata, inferred that they were deposited, not in the sea, as had always been asserted, but in a great fresh-water lake or in a series of lakes. In this opinion I have for many years agreed, for the nearest analogies of the fish are, according to Huxley, the Polypterus of African rivers, the Ceratodus of Australia, and in less degree the Lepidosteus of North America. The truth of the supposition that the Old Red Sandstone was deposited in fresh water is further borne out by the occurrence of a fresh-water shell, *Anodonta jukesii*, and of ferns in the Upper Old Red Sandstone in Ireland; and the same shell is found at Dura Den in Scotland, while in Caithness, along with numerous fishes, there occurs the small bivalve crustacean *Estheria murchisonia*.

I think it more than probable that the red series of rocks that form the Catskill Mountains of North America (and with which I am personally acquainted) were formed in the same manner as the Old Red Sandstones of Britain: for, excepting in one or two minor interstratifications, they contain no relics of marine life, while "the fossil fishes of the Catskill beds, according to Dr. Newberry, appear to represent closely those of the British Old Red Sandstone." (Dana.)

The Devonian rocks of Russia, according to the late Sir Roderick Murchison, consist of two distinct types, viz., Devonian strata identical in general character with those in Devonshire and in various parts of the continent of Europe. These are exclusively of a marine character, while the re-

* Many earlier notices and descriptions of the Salt Range might be quoted, but Mr. Wynne's is enough for my purpose.

† See "Physical Geology and Geography of Great Britain," fifth edition, where the question is treated in more detail.

* By Cambrian I mean only the *red and purple* rocks of Wales, England, Scotland, and Ireland, older than the Menevian beds, or any later division of the Silurian strata that may chance to rest upon them.

† "On the Red Rocks of England of Older Date than the Trias."—*Jour. Geol. Soc.*, 1871, vol. xxviii.

mainder corresponds to the Old Red Sandstone of Wales, England, and Scotland.

At Tchudora, about 105 miles S.E. of St. Petersburg, the lowest members of the series consist of flag-like compact limestones accumulated in a tranquil sea and containing fucoids and encrinites, together with shells of Devonian age, such as Spirifers, Terebratulæ, Orthis, Leptænas, Avicula, Modiola, Natica, Bellerophon, &c., while the upper division graduates into the Carboniferous series as it often does in Britain, and, like the Old Red Sandstone of Scotland, contains only fish-remains, and in both countries they are of the same species. "Proceeding from the Valdai Hills on the north," the geologist "quits *a Devonian Zone with a true 'Old Red' type* dipping under the Carboniferous rocks of Moscow, and having passed through the latter, he finds himself suddenly in a yellow colored region, entirely dissimilar in structure to what he had seen in any of the northern governments, which, of a different type as regards fossils, is the true stratigraphical *equivalent of the Old Red System.*" This seems to me, as regards the Russian strata, to mean, that just as the Devonian strata of Devonshire are the true equivalents of the Old Red Sandstone of Wales and Scotland, they were deposited under very different conditions, the first in the sea and the others in inland fresh-water lakes. At the time Sir Roderick Murchison's work was completed, the almost universal opinion was that the Old Red Sandstone was a marine formation. In the year 1830 the Rev. Dr. Fleming, of Edinburgh, read a paper before the Wernerian Society, in which he boldly stated that the "*Old Red Sandstone* is a *fresh-water formation*" of older date than the Carboniferous Limestone. This statement, however, seems to have made no impression on geologists till it was revived by Godwin-Austen in a memoir "On the Extension of the Coal-measures," etc., in the *Journal of the Geological Society*, 1856. Even this made no converts to what was then considered a heretical opinion. I have long held Dr. Fleming's view, and unfortunately published it in the third edition of "The Physical Geology and Geography of Great Britain," without at the time being aware that I had been forestalled by Dr. Fleming and Mr. Godwin-Austen.

To give anything like a detailed account of all the fresh-water formations deposited in estuaries and lakes from the close of the Old Red Sandstone times down to late Tertiary epochs is only fitted for a manual of geology, and would too much expand this address, and I will therefore give little more than a catalogue of these deposits in ascending order.

In the Coal-measure parts of the Carboniferous series a great proportion of the shales and sandstones are of fresh-water origin. This is proved all over the British Islands by the shells they contain, while here and there marine interstratifications occur, generally of no great thickness. There is no doubt among geologists that these Coal-measure strata were chiefly deposited under estuarine conditions, and sometimes in lagoons or in lakes; while numerous beds of coal formed by the life and death of land plants, each underlaid by the soil on which the plants grew, evince the constant recurrence of terrestrial conditions. The same kind of phenomena are characteristic of the Coal-measures all through North America, and in every country on the continent of Europe, from France and Spain on the west, to Russia in the east, and the same is the case in China and in other areas.

In Scotland, according to Prof. Judd, fresh-water conditions occur more or less all through the Jurassic series, from the Lias to the Upper Oolites. In England, fresh-water strata, with thin beds of coal, are found in the Inferior Oolite of Yorkshire, and in the middle of England and elsewhere in the Great Oolite. The Purbeck and Wealden strata, which, in a sense, fill the interval between the Jurassic and Cretaceous series, are almost entirely formed of fresh-water strata, with occasional thin marine interstratifications. By some the Wealden beds are considered to have been formed in and near the estuary of a great river, while others, with as good a show of reason, believe them to have been deposited in a large lake subject to the occasional influx of the sea.

In the eastern part of South Russia the Lias consists chiefly of fresh-water strata, as stated by Neumayr.

The Godwana rocks of Central India range from Upper Paleozoic times well in the Jurassic strata, and there all these formations are of fresh-water origin. Fresh-water beds with shells are also interstratified with the Deccan traps of Cretaceous and Tertiary (Eocene) age, while 2,000 feet of fresh-water sands overlie them.

In South-western Sweden, as stated by Mr. Bauermann, "the three coalfields of Hoganas, Stabbarp, and Rodingé, lie in the uppermost Triassic or Rhætic series." In Africa, the Karoo beds, which it is surmised may be of the age of the New Red Sandstone, contain beds of coal. In North America, certain fresh water strata, with beds of lignite, apparently belong to the Cretaceous and Eocene epochs, and in the north of Spain and South of France there are fresh-water lacustrine formations in the highest Cretaceous strata.

In England the lower and upper Eocene strata are chiefly of fresh-water origin, and the same is the case in France and other parts of the Continent. Certain fresh-water formations in Central Spain extend from the Eocene to the upper Miocene strata.

There is only one small patch of Miocene beds in England, at Bovey Tracey, near Dartmoor, formed of fresh-water deposits with interstratified beds of lignite or Miocene coal. On the continent of Europe Miocene strata occupy immense independent areas, extending from France and Spain to the Black Sea. In places too numerous to name, they contain beds of "brown coal," as lignite is sometimes called. These coal-beds are often of great thickness and solidity. In one of the pits which I descended near Teplitz, in Bohemia, the coal, which lies in a true basin, is 40 feet thick, and underneath it there is a bed of clay, with rootlets, quite comparable to the underclay which is found beneath almost every bed of coal in the British and other coal-fields of the Carboniferous epoch. The Miocene rocks of Switzerland are familiar to all geologists who have traversed the country between the Jura and the Alps. Sometimes they are soft and incoherent, sometimes formed of sandstones, and sometimes of conglomerates, as on the Righi. They chiefly consist of fresh-water acustrine strata, with some minor marine interstratifications which mark the influx of the sea during occasional partial submergences of portions of the area. These fresh-water strata, of great extent and thickness, contain beds of lignite, and are remarkable for the relics of numerous trees and other plants, which have been described by Prof. Heer, of Zurich, with his accustomed skill. The Miocene fresh-water strata, of the Sewalik Hills in India, are well known to most students of geology, and I have already stated that they bear the same relation to the more ancient Himalayan Mountains that the Miocene strata of Switzerland and the north of Italy do to the pre-existing range of the Alps. In fact, it may be safely inferred that something far more than the rudiments of our present continents existed long before Miocene times, and this accounts for the large areas on those continents which are frequently occupied by Miocene fresh-water strata. With the marine formations of Miocene age this address is in no way concerned, nor is it essential to my argument to deal with those later tertiary phenomena, which, in their upper stages, so easily merge into the existing state of the world.

GLACIAL PHENOMENA.

I now come to the last special subject for discussion in this address, viz., the Recurrence of Glacial Epochs, a subject still considered by many to be heretical, and which was generally looked upon as an absurd crotchet when, in 1855, I first described to the Geological Society, bowlder-beds, containing ice-scratched stones, and erratic blocks in the Permian strata of England. The same idea I afterwards applied to some of the Old Red Sandstone conglomerates, and of late years it has become so familiar that the effects of glaciers have at length been noted by geologists from older Paleozoic epochs down to the present day.

In the middle of last July I received a letter from Prof. Geikie, in which he informed me that he had discovered mammillated *moutonnée* surfaces of Laurentian rocks, passing underneath the Cambrian sandstones of the northwest of Scotland, at intervals, all the way from Cape Wrath to Loch Torridon, for a distance of about 90 miles. The mammillated rocks are, says Prof. Geikie, "*as well rounded off as any recent roche moutonnée*," and, "in one place these bosses are covered by a huge angular breccia of this old gneiss (Laurentian) with blocks sometimes five or six feet long." This breccia, where it occurs, forms the base of the Cambrian strata of Sutherland, Ross, and Cromarty, and while the higher strata are always well stratified, where they approach the underlying Laurentian gneiss, "they become pebbly, passing into coarse unstratified agglomerates or bowlder-beds." In the Gairloch district "it is utterly unstratified, the angular fragments standing on end and at all angles," just as they do in many modern moraine mounds wherever large glaciers are found. The general subject of Paleozoic glaciers has long been familiar to me, and this account of more ancient glaciers of Cambrian age is peculiarly acceptable.

The next sign of ice in Britain is found in the Lower Silurian Rocks of Wigtonshire and Ayrshire. In the year 1865, Mr. John Carrick Moore took me to see the Lower Silurian graptolitic rocks at Corswall Point, in Wigtonshire, in which great blocks of gneiss, granite, etc., are embedded, and in the same year many similar erratic blocks were pointed out to me by Mr. James Geikie in the Silurian strata of Carrick, in Ayrshire. One of the blocks at Corswall, as measured by myself, is nine feet in length, and the rest are of all sizes, from an inch or two up to several feet in diameter. There is no gneiss or granite in this region nearer than those of Kirkcudbrightshire and Arran, *and these are of later geological date than the strata amid which the erratic blocks are embedded.* It is, therefore, not improbable that they may have been derived from some high land formed of Laurentian rocks, of which the outer Hebrides and parts of the mainland of Scotland form surviving portions. If so, then I can conceive of no agent capable of transporting large bowlders and dropping them into the Lower Silurian mud of the seas of the time save that of icebergs or other floating ice, and the same view with regard to the neighboring bowlder-beds of Ayrshire is held by Mr. James Geikie. If, however, any one will point out any other natural cause still in action, by which such results are at present brought about, I should be very glad to hear of it.

I must now turn to India for further evidence of the action of paleozoic ice. In the Himalayas of Pangi, S. E. of Kashmir, according to Medlicott and Blanford, "old slates, supposed to be Silurian, contain bowlders in great numbers," which they believe to be of glacial origin. Another case is mentioned as occurring in "transition beds of unknown relations;" but in another passage they are stated to be "very ancient, but no idea can be formed of their geological position." The *underlying rocks are marked by distinct glacial striations.*

The next case of glacial bowlder-beds with which I am acquainted is found in Scotland, and in some places in the north of England, where they contain what seem to be indistinctly ice-scratched stones. I first observed these rocks on the Lammermuir Hills, south of Dunbar, lying unconformably on Lower Silurian strata, and soon inferred them to be of glacial origin, a circumstance that was subsequently confirmed by my colleagues, Prof. and Mr. James Geikie, and is now familiar to other officers of the Geological Survey of Scotland.

I know of no bowlder formations in the Carboniferous series, but they are well known as occurring on a large scale in the Permian brecciated conglomerates, where they consist "of pebbles and large blocks of stone, generally angular, embedded in a marly paste, . . . the fragments have mostly traveled from a distance, apparently from the borders of Wales, and some of them are three feet in diameter." Some of the stones are as well scratched as those found in modern moraines or in the ordinary bowlder-clay of what is commonly called the Glacial Epoch. In 1855, the old idea was still not unprevalent that during the Permian Epoch, and for long after, the globe had not yet cooled sufficiently to allow of the climates of the external world being universally affected by the constant radiation of heat from its interior. For a long time, however, this idea has almost entirely vanished, and now, in Britain at all events, it is little, if at all, attended to; and other glacial episodes in the history of the world have continued to be brought forward, and are no longer looked upon as mere ill-judged conjectures.

The same kind of brecciated bowlder-beds that are found in our Permian strata occur in the Rotheliegende of Germany, which I have visited in several places, and I believe them to have had a like glacial origin.

Mr. G. W. Stow, of the Orange Free State, has of late years given most elaborate accounts of similar Permian bowlder-beds in South Africa. There, great masses of moraine matter not only contain ice-scratched stones, but on the banks of rivers, where the Permian rock has been removed by aqueous denudation, the underlying rocks, well rounded and mammillated, *are covered by deeply incised glacier grooves* pointing in a direction which at length leads the observer to the pre-Permian mountains, from whence the stones were derived that formed these ancient moraines.*

Messrs. Blanford and Medlicott have also given in "The Geology of India" an account of bowlder-beds in what they believe to be Permian strata, and which they compare with those described by me in England many years before. There the Godwana group of the Talchir strata contains numerous bowlders, many of them six feet in diameter, and "in one instance *some of the blocks were found to be polished and striated, and the underlying Vindhyan rocks were similarly marked.*" The authors also correlate these glacial phenomena with those found in similar deposits in South Africa, discovered and described by Mr. Stow.

In the Olive group of the Salt range, described by the same authors, there is a curious resemblance between a certain conglomerate "and that of the Talchir group of the Godwana system." This "Olive conglomerate" belongs to the Cretaceous series, and contains ice-transported erratic bowlders derived from unknown rocks, one of which, of red granite, "is polished and striated on three faces in so characteristic a manner that very little doubt can exist of its having been transported by ice." One block of red granite, at the Mayo salt mines of Khewra, "is 7 feet high and 19 feet in circumference." In the "Transition beds" of the same authors, which are supposed to be of Upper Cretaceous age, there also are bowlder-beds with erratic blocks of great size.

I know of no evidence of glacial phenomena in Eocene strata excepting the occurrence of huge masses of included gneiss in the strata known as Flysch, in Switzerland. On this question, however, Swiss geologists are by no means agreed, and I attach little or no importance to it, as affording evidence of glacier ice.

Neither do I know of any Miocene glacier deposits, excepting those in the north of Italy, near Turin, described by the late eminent geologist, Gastaldi, and which I saw under his guidance. These contain many large erratic bowlders derived from the distant Alps, which, in my opinion, were then at least as lofty or even higher than they are now, especially if we consider the immense amount of denudation which they underwent during Miocene, later Tertiary, and post-Tertiary times.

At a still later date there took place in the north of Europe and America what is usually misnamed "*The* Glacial Epoch," when a vast glacial mass covered all Scandinavia, and distributed its bowlders across the north of Germany, as far south as the country around Leipzig, when Ireland also was shrouded in glacier ice, and when a great glacier covered the larger part of Britain, and stretched southward, perhaps nearly as far as the Thames on the one side, and certainly covered the whole of Anglesey, and probably the whole, or nearly the whole, of South Wales. This was after the advent of man.

Lastly, there is still a minor Glacial Epoch in progress on the large and almost unknown Antarctic continent, from the high land of which, in latitudes which partly lie as far north as 60° and 62°, a vast sheet of glacier ice, of great thickness, extends far out to sea, and sends fleets of icebergs to the north, there to melt in warmer latitudes. If in accordance with the theory of Mr. Croll, founded on astronomical data, a similar climate were transferred to the northern hemisphere, the whole of Scandinavia and the Baltic would apparently be covered with glacier ice, and the same would probably be the case with the Faroe Islands and great part of Siberia, while even the mountain tracts of Britain might again maintain their minor systems of glaciers.

CONCLUSIONS.

In opening this address, I began with the subject of the oldest metamorphic rocks that I have seen—the Laurentian strata. It is evident to every person who thinks on the subject that their deposition took place *far from the beginning of recognized geological time.* For there must have been older rocks by the degradation of which they were formed. And if, as some American geologists affirm, there are on that continent metamorphic rocks of more ancient dates than the Laurentian strata, there must have been rocks more ancient still to afford materials for the deposition of these pre-Laurentian strata.

Starting with the Laurentian rocks, I have shown that the phenomena of *metamorphism* of strata have been continued from that date all through the later formations, or groups of formations, down to and including part of the Eocene strata in some parts of the world.

In like manner I have shown that ordinary volcanic rocks have been ejected in Silurian, Devonian, Carboniferous, Jurassic, Cretaceo-oolitic, Cretaceous, Eocene, Miocene, and Pliocene times, and from all that I have seen or read of these ancient volcanoes, I have no reason to believe that volcanic forces played a more important part in any period of geological time than they do in this our modern epoch.

So, also, mountain chains existed before the deposition of the Silurian rocks, others of later date before the Old Red Sandstone strata were formed, and the chain of the Ural before the deposition of the Permian beds. The last great upheaval of the Allegheny Mountains took place between the close of the formation of the Carboniferous strata of that region and the deposition of the New Red Sandstone.

According to Darwin, after various oscillations of level, the Cordillera underwent its chief upheaval after the Cretaceous epoch, and all geologists know that the Alps, the Pyrenees, the Carpathians, the Himalayas, and other mountain chains (which I have named), underwent what seems to have been their chief great upheaval after the deposition of the Eocene strata, while some of them were again lifted up several thousands of feet after the close of the Miocene epoch.

The deposition of salts from aqueous solutions in inland lakes and lagoons appears to have taken place through all time—through Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene, Miocene, and Pliocene epochs—and it is going on now.

In like manner, fresh water and estuarine conditions are found now in one region, now in another, throughout all the formations, or groups of formations, possibly from Silurian times onward; and glacial phenomena, so far from being confined to what was and is generally still termed *the* Glacial Epoch, are now boldly declared, by independent witnesses of known high reputation, to begin with the Cambrian epoch, and to have occurred somewhere, at intervals, in various formations, from almost the earliest Paleozoic times down to our last post-Pliocene "Glacial Epoch."

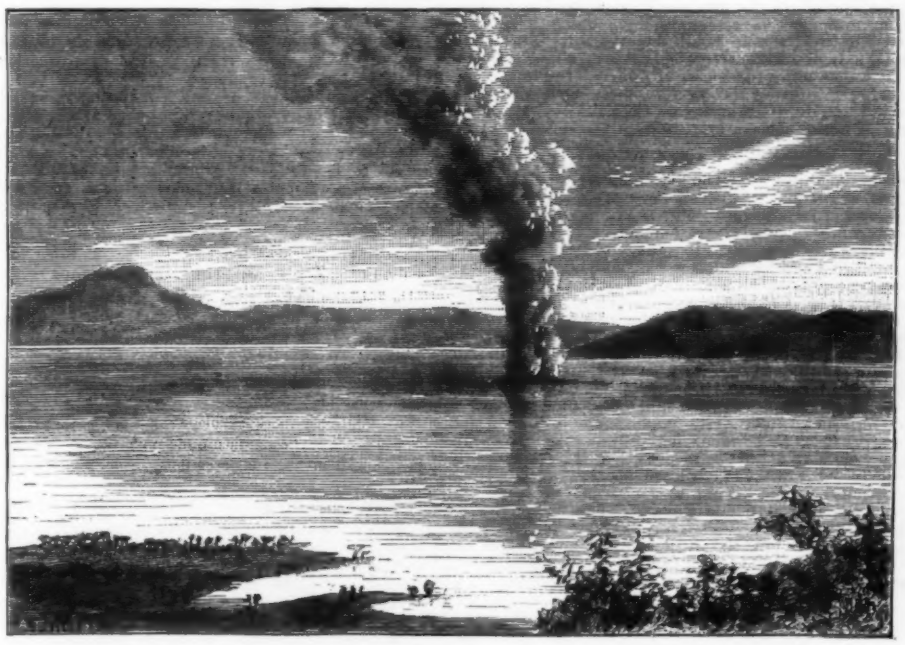
If the nebular hypothesis of astronomers be true (and I know of no reason why it should be doubted), the earth was at one time in a purely gaseous state, and afterwards in a fluid condition, attended by intense heat. By and by, consolidation, due to partial cooling, took place on the surface,

* Mr. Stow's last memoir on this subject is still in manuscript. It is so exceedingly long, and the sections that accompany it are of such unusual size, that the Geological Society could not afford their publication. It was thought that the Government of the Orange Free State might undertake this duty, but the late troubles in South Africa have probably hindered this work—it is to be hoped only for a time.

and as radiation of heat went on, the outer shell thickened. Radiation still going on, the interior fluid matter decreased in bulk, and, by force of gravitation, the outer shell being drawn towards the interior, gave way, and, in parts, got crinkled up, and this, according to cosmogonists, was the origin of the earliest mountain chains. I make no objection to the hypothesis, which, to say the least, seems to be the best that can be offered, and looks highly probable. But, assuming that it is true, these hypothetical events took place so long before authentic geological history began, as written in the rocks, that the earliest of the physical events to which I have drawn your attention in this address, was, to all human apprehension of time, so enormously removed from these early assumed cosmical phenomena, *that they appear to me to have been of comparatively quite modern occurrence, and to indicate that, from the Laurentian epoch down to the present day, all the physical events in the history of the earth have varied neither in kind nor in intensity from those of which we now have experience.* Perhaps many of our British geologists hold similar opinions, but, if it be so, it may not be altogether useless to have considered the various subjects separately on which I depend to prove the point I had in view.

THE NEW VOLCANO IN LAKE ILOPANGO, REPUBLIC OF SAN SALVADOR.

THE details in regard to an interesting geological phenomenon—the recent appearance of a volcano in the midst of Lake Ilopango, San Salvador—have lately been communicated to the Academie des Sciences, by M. de Lesseps, and been noticed in scientific periodicals. M. Laferriere, the consul of the Republic of San Salvador, has furnished the editor of *La Nature* with still further information, as well as photographs of the volcano, both of which we borrow from that journal. The accompanying cut shows the nature of the new crater which arose from the waters of the lake. Seen at a distance it looks like a small island, yet it really rises to a height of at least sixty-five feet above the surface of the water. An attempt has been made to approach it by



VIEW OF THE NEW VOLCANO IN LAKE ILOPANGO.

(FROM A PHOTOGRAPH.)

boat, but the waters in contact with the burning rock are in a state of ebullition and give out clouds of steam. A great column of smoke ascends from it into the atmosphere, and spreads so as to have the aspect of an immense feathery cloud, which can be seen at a great distance, and produces on the beholder a grand and imposing effect.

Earthquakes were felt in the Republic of San Salvador during the first half of the month of January, 1880; there were only three shocks, and they were less violent than those of 1876, not a single house being injured. These earthquakes had their center in the vicinity of Lake Ilopango, and in the middle of this rose the new volcano under consideration, and which consists of three united craters. The phenomenon was preceded by an exceptional increase of the lake, which was swollen by the copious rains of winter. According to an ancient tradition, the Spaniards assert, that when the level of the lake rises, earthquakes are to be expected. For this reason it used to be an old custom to dig channels to facilitate the outflow of the waters. This practice was kept up uninterruptedly for a century, and no volcanic phenomena manifested themselves during this whole space of time. The present phenomena seem to give some credence to the tradition. If it is difficult to explain this fact, it is none the less interesting to bear in mind that a large number of volcanoes are submarine; that others are found in most cases in islands or maritime regions; and that water may possibly be one of the aliments of these volcanic fires. Lake Ilopango (also known as Lake Cojutepeque) is, according to M. Laferriere, a sunken crater. It is on the line of a volcano; and it is a general fact that, in Central America, the lakes alternate with volcanic cones. The water of this lake is brackish, very bitter, and almost viscid. It occasionally gives out, here and there, bubbles of hydrosulphuric acid. The lake is no less than fifteen miles long by ten miles wide; its depth is unknown. It is situated at about eight miles from San Salvador. According to a letter recently received from M. de Thiersant, the French consul at Guatemala, the waters of the lake are still at a temperature of 38° C. at the shores, and in lively ebullition around the volcano. All the fishes are completely boiled, and, with a large number of mollusks and aquatic animals are floating on the surface. The mountain is continually rising, and the level of the lake is progressively lowering.

A FRESH-WATER MEDUSA.

IT was recently discovered that a fresh-water jelly fish was living and multiplying abundantly in the water-lily tank of the Botanical Garden, Regent's Park, London.

The diameter of the swimming bell does not exceed one-third of an inch—the fresh-water stranger being thus a comparatively small-sized member of the race. It occurs in fresh water maintained at a temperature of 90° Fah.; and the problem of its occurrence in Regent's Park is perhaps best solved on the supposition that it is an introduced tropical species, which, until the present summer, has not been developed in sufficient numbers to attract notice; while its small size, added to a lack of numbers, may perfectly account for its being hitherto overlooked. Like other medusæ, the new comer, which has received the name of *Limnocodium sowerbii*, feeds on minute forms of animal life—Mr. Sowerby recording its capture of the "branch-horned water flea" (*Daphnia pulex*) in large numbers. There is an extreme paucity of female medusæ among the Regent's Park specimens. The reason for this, and the preponderance of the sterner sex, is a difficult matter to say anything about—considering our lack of knowledge of the animal's original *habitat*, and our inability to say whether the conditions under which it is now living are such as to favor the development of one sex over that of the other. One of the most important questions connected with the new medusa is that of its origin and occurrence in fresh water. Mr. Romanes has been experimenting on this subject. A marine medusa suddenly transferred to fresh water and left there remains motionless until it dies. Fifteen minutes in fresh water kills an ordinary jelly fish. When the new medusa, on the other hand, is placed in sea water at 85°, it exhibits passiveness in about a minute; and it may ultimately die, even when restored to fresh water. Similar or analogous results follow the immersion of the new jelly fish in weak solutions of salt water, and Mr. Romanes argues that the change of constitution which has adapted a marine jelly fish to fresh water is more sweeping than that which could adapt a salt water species to live among brine. "Sea water is now more poisonous to the modified" (or fresh water) "species than is fresh water to the unmodified" (or marine), says Mr. Romanes; and one can but agree with this naturalist when he argues for the marine ancestry of the fresh-water jelly fish, and for its gradual modification through life in the brackish water of estuaries, to an existence in the fresh water of rivers. Such a hypothetical case is not unparalleled elsewhere in the animal world. One has only to think of the case of the opossum-shrimp (*Mysis relicta*) of the fresh-water lakes of Northern Europe and of North America. This crustacean is barely distinguishable from the *Mysis oculata* of the Arctic seas. Now, we have evidence that the lakes of Norway and Sweden were once mere arms of the sea, and were converted into lakes by physical change. Hence *Mysis oculata* of the sea has become *Mysis relicta* of the lakes by the slow modification of its constitution due to the change in surroundings, just as the fresh-water jelly fish, once marine, has become modified for a new existence. As Mr. Romanes remarks of the new jelly fish: "If an animal so exceedingly intolerant of fresh water as is a marine jelly fish may yet have all its tissues changed so as to adapt them to thrive in fresh water, and even die after an exposure of one minute to their ancestral element—assuredly we can see no reason why any animal in earth, sea, or anywhere else, may not in time become fitted to change its element."

PACIFIC SALMON.

REVIEWING the recent work of the U. S. Fish Commission on the Pacific coast, the superintendent of that division of the work, Prof. David S. Jordan, lately gave the Californian Academy of Sciences some interesting information with regard to the habits of coast salmon.

There are only five species of salmon on the whole coast. When they are in superior condition their flesh is a deep red. Old males, as they approach the spawning age and season, become nearly white. They are then out of condition for food. In autumn they undergo certain rapid changes of condition. Their form becomes distorted, their backs arched, and their whole form becomes deeper and less asymmetrical, quite unlike their regular and beautiful figure in spring. Their jaws enlarge, and teeth change in form and number. They run up rivers, and the female spawn, after which all die. The reason of this universal death after the spawning season is not yet fully determined. They are hatched in clear water, in the shallow streams, brooks, and rivulets of the interior connecting with the ocean. They descend to the sea when three to four inches long, and after a long absence return at about the age of four years. When they approach the coast, they become attracted by the strata or currents of fresh water flowing from rivers. When at sea they feed freely and bite vigorously at a hook, but as soon as they enter fresh water and mount up the rivers, they cease entirely to eat anything, and therefore never take a hook. When thus caught their stomachs are always empty. As soon as they begin to fast their features begin to become sharper, and they rapidly become what fishermen call dog-salmon. They appear then impressed with an irresistible desire to penetrate fresh water streams as nearly to their fountain heads as possible, and follow the sources of the Columbia River as far as Montana. During this rapid journey they distribute their spawn, and keep on going until the water is so shallow they can barely crawl up stream farther; then they batter themselves up, and in October, having spawned, all die, and none ever return to the sea.

It was the opinion of Professor Jordan that they die of pure exhaustion, as all become more or less bruised by rocks and none show any evidence of having tasted food since leaving the ocean. Ventura River is the farthest south that any salmon run up rivers, as few rivers below this have any direct outlet to the sea, but run through such obstructions as sand bars. At Columbia River, from April to July, there are from 1,500 to 2,000 boats out salmon-fishing all the time, extending from the bar clear up to off Mount Ranier, forming a perfectly impenetrable web of nets.

THE COLORADO POTATO BEETLE.

PROF. RILEY was the first to make known the natural history and transformations of the potato beetle, in the *Prairie Farmer* for August 8, 1863, and they may be briefly summed up as follows: The female beetle deposits her eggs on the underside of the leaves, in clusters of a dozen up to fifty or more. The eggs are of an orange color, and hatch in about a week after being laid, the grubs immediately commencing to feed and continuing until mature, which occurs in from fourteen to eighteen days, varying somewhat as the weather may be favorable or unfavorable. When full grown, the larvæ descend to the ground and hide under leaves or rubbish, or burrow into the soil, where they remain for about ten days, then come forth in the perfect or winged form. Two to four broods are perfected during the season, according to the locality and length of the season, the last brood descending into the ground in the perfect or beetle state, and remaining in a dormant condition over winter—reappearing as soon as the ground has become sufficiently warm to awaken them from their long slumbers. The beetles at this time may usually be seen crawling about very rapidly, looking for the first shoots of the potato as it appears above ground, which they attack as though their appetite had been sharpened by a long fast.

METHOD OF DESTROYING.

The first step or most practical method of making war upon this insect is the destruction of the few or many that come out of the ground in spring, for each female killed at this time may safely be said to represent five to ten hundred in the succeeding generation, for she will, if not prevented, lay about that number of eggs. Some persons, however, claim that it is much the best way to allow the beetles to take their own course, and then destroy the larvæ a few days later, when they have fairly commenced feeding upon the leaves, by applying some one or more of the various poisons recommended for this purpose. That either the beetles or the grubs must be destroyed in order to save the crop, is now generally admitted, and the only room for a difference of opinion is as to how it should be done. Scores of different substances have been tried for this purpose, copperas, lime, mandrake tea, and other common insecticides, but none have proved so effectual and economical as Paris green and other arsenical compounds. That these poisons are dangerous to have about a place is admitted, and so are sharp knives, reapers, and mowers, still it is not as easy to do without them as to be a little careful in using, and thereby avoid accidents. The Paris green is destructive to the potato beetle in both its perfect and larval states, and one pound of the poison, mixed with twenty of pulverized plaster, or of any common kind of flour, and dusted over the leaves while wet with dew in the morning, or after a shower, will quickly cause the death of all the grubs or perfect insects feeding thereon.

A duster should be used for applying the poison, and one made of tin, with a perforated bottom, and attached to a handle four or five feet long, will be found a very convenient implement for this purpose. But the operator should be careful not to allow the compound to blow into his face, or inhale it while at work, it being only necessary for him to keep in mind that he is handling a virulent poison, and act accordingly. The green may also be applied by mixing it with water, but as it will not dissolve, but is merely suspended in the liquid, it is necessary to frequently agitate the mixture in order to prevent the poison settling to the bottom, as well as to insure its uniform distribution over the leaves. But water is a heavy material to handle, and unless one has the conveniences for applying it, the dusting process will be found the most economical as requiring the least labor.

The recently introduced London purple may be applied in the same way as Paris green, and will prove equally effective, besides being much cheaper.—*A. S. F., in American Entomologist.*

CANARY BIRDS—HOW TO CARE FOR THEM.

So many questions are asked us about canary birds, especially as to care, breeding, etc., that we reply to them in a general article. This pretty little captive bird—and its prison is a happy one, or should be made so—gets its common name from the Canary Isles, where it abounds in its wild state, and is clothed in a gray or brown plumage, quite in contrast with the white, yellow, and green of the domesticated varieties. The canary birds have long been esteemed for their beauty and melody, and were domesticated in Europe nearly three centuries ago, where, at the present time, they are bred on an extensive scale, especially in France and Germany, from which countries we import them by the tens of thousands. The canary bird trade is vastly greater than would be supposed by those who have not looked into the subject. In England there have been annual shows—and what beautiful shows they must be!—for the last half century, at which large prizes have been awarded among the different varieties, which are reckoned

up by dozens. So far as looks are concerned, a bird is valued according to the purity of its coloring, or if mixed, in proportion as the markings are regular. A mottled or spotted bird is not held in much esteem, while one which is a pure yellow, or a yellow with black wings and tail, is greatly prized. But above the color is the song; and in the choice of a bird it is best to observe the rule, "Sacrifice color to accomplishments." Nature seldom unites rare beauty and great accomplishments. A person should not reject a sweet singer because its tail feathers are gone; they will soon come out; but this cannot be said of the voice where it is wanting. Some estimate a bird's value by the loudness of the voice; we prefer the softer—and we think sweeter—tones, in fact, have almost been incensed by the *noise* which some birds will make when they sing.

First, as to cages, of which there are many different styles, but none should sacrifice the comfort of the bird or endanger its life. The large wooden frame cages are fast passing out of date, and are superseded by those made entirely of metal, which are neater, lighter, easier cleaned, and less liable to harbor insects. The wires, against which a bird will often pick more or less, should never be coated with paint, as it may cause its death. Ample provision should be made for food and water within the cages, and there should be a proper arrangement for hanging it up. A hook or a stout ring is better to hang it by than a ribbon, which in time will wear out, when the cage and contents may have a fall. Perches and a swing will, of course, be provided. Canaries are very fond of a bath, and should be given water for one nearly every day. The tub should be removed when the bath is over. To see the little fellow enjoy the splashing and fluttering is worth all the trouble. Above all things in the keeping of birds, neatness is of the greatest importance. They need attention *every* day. If the bird is "too much of a trouble," then do not keep it a day. Birds are very tender things, and as such are very susceptible to treatment, good or bad. They should have a plenty of air and light, but not the dazzling sunshine. A bird should not be out-of doors when the air is at all chilly; and in winter it is cruel to leave it in a room in which the temperature goes down to freezing or below.

"What shall we feed our birds?" is a question frequently asked, and it is an important one, as their health depends largely upon their food. Do not dose them with sweetmeats, their systems demand a plain diet. The natural food of the canaries is seeds and green herbage, and a mixture of rape, canary, and hemp seed, together with chickweed, cress, cabbage, etc., is found to be the most healthful. A cuttle-fish bone (sold at the drug stores) hung in the cage will furnish the lime they need, and which they find in the wild state.

Perhaps the most important point is to know what to do when the bird is sick. With proper care they seldom sicken, but sometimes illness is unavoidable. Birds will, without any apparent reason, take colds, followed by sneezing and hoarseness. For this a bit of licorice, put in the drinking water, proves beneficial. In case of loss of appetite, shedding of feathers, and general decline, a plenty of water-cress is valuable. Young birds are frequently troubled with "gapes," and should have an abundance of green food and be kept in a warm place. Canaries that are not properly cared for will be infested with lice, for which a little anise seed mixed with the gravel on the floor is a preventive. Epilepsy is caused by too rich food; the cure is in quiet and a simpler diet. In cases of diarrhea put a rusty nail in the drinking water, and chalk, broken fine, on the floor, omitting all green food. A bird well cared for—and the care is by no means great—is a cheerful and cheering companion. If one loves such a pet—and most people do—the care is more than repaid in bright plumage, graceful actions, and sweet music of these little birds.—*American Agriculturist.*

THE COTTON CROP AND ITS POSSIBILITIES.

IN a letter to the New York *Herald* proposing a great exhibition devoted exclusively to cotton, Mr. Edward Atkinson, of Boston, discusses the American cotton crop and its possibilities as follows:

THE REIGN OF COTTON.

The true forces now in action in the South are industrial forces; the opportunities to apply improvements and inventions, and for the accumulation of widely diffused wealth by rightful methods. The true reconstruction and the real union that are now being consummated are by means of these industrial forces, and in this work cotton has been and will be the most potent force of all. For a century the limitations of slavery kept the treatment of the cotton plant subject to the most barbarous conditions, with the use of the rudest tools and most wasteful methods. No matter how intelligent the planters might be (and no more intelligent men could have been found cultivating the land in any country in the world than a portion of their number), they were yet restricted by their system of labor to the most unfit and wasteful methods. Slavery may have had some moral and political compensations to offset its evils, but as a system of labor there was no compensation. To the economist it presented nothing but the most conclusive evidence of absurdly wasteful barbarism. It was neither cheap, effective, nor productive. Since liberty gave the opportunity for change a vast progress has been made. The very habit of the cotton plant itself has been altered. It has been forced to mature earlier. It has been made stronger to resist its insect enemies. It has been made more prolific, and although the testimony is almost conclusive that the laborers in the cotton fields are now less numerous than before the war, because more males and less women and children are now worked, their labor is so much more effective that the fifteen crops of free labor exceed the fifteen last crops made by the labor of slaves by 9,600,000 bales, worth in gold coin fully $600,000,000. When the crop now about to be gathered is numbered, if the season end as propitiously as it has begun, it will be more than double the average of the fifteen ante-war crops, and at least twenty-five per cent. in excess of the largest crop ever raised by the labor of slaves.

NEW VALUES FOR THE CROP.

Nevertheless what has been done is but a tithe of what remains; the present power of King Cotton is but the shadow of the substance yet to come. The value of the seed is yet an unknown quantity. It may seem almost the work of a visionary to compute it. If we make 6,000,000 bales of cotton fiber in a year the weight of cotton seed that will remain after enough has been set aside for the next year's planting will be 3,000,000 tons. If the whole of this seed be treated as a small portion is now treated this seed will give the following results: About 90,000,000 gallons of oil, about 1,800,000 tons of oilcake or meal, about 1,500,000 tons of hulls, from which there is every reason to suppose from experiments here and actual use elsewhere, that 750,000 tons of paper may be made. Otherwise these hulls ground into meal with the oilcake will serve as food for stock—2,800,000 tons in all. Each ton of this ground meal would carry at least five sheep six months, the rest of the year they would have ample food from the annual grasses that are the pest of the cotton planter, or from corn fodder, cow peas, or other refuse or alternate crops. The waste of the cotton gin and of the oil press, with other waste of the cotton farm, will therefore suffice for not less than 14,000,000 to 20,000,000 sheep, probably for double that number. These sheep, folded upon the cotton field, would so fertilize the soil as to double the crop of cotton on any given acre of uplands—the manure of animals fed on cotton seed meal being richer than that from any other known variety of food.

STARTLING FIGURES.

The almost unrealized portion of the product of a single year's cultivation of the cotton plant on the area now in use for that purpose (about 13,000,000 acres, or less than two per cent. of the area of the cotton States) may therefore consist of 75,000,000 to 90,000,000 gallons of oil, 500,000 to 750,000 tons of paper, or 50,000,000 to 100,000,000 pounds of fine clothing wool; and as an incident of this progress, 50 to 100 per cent. more cotton fiber from the same area of land now cultivated will be produced with less labor than is now expended, because the large crop on a fertile acre can be picked with as little labor as the small crop on a sterile one, and the limit of the production of cotton is in the power of picking the cotton, not in the power of cultivating. We have already precluded critics by saying that these estimates may be deemed visionary, but we are warranted by known facts in saying that the measure of their realization will only consist in the measure of intelligence applied to this branch of agriculture.

NEW TRADE FOR THE NORTH.

In connection with this industrial prophecy made possible by freedom, it should be considered that there never was so great a field suddenly opened for the introduction of new tools, new cotton gins, new presses, and for every variety of implements and processes. Whence are they to come if not from the North? If the new conditions make the interdependence of the sections essential and imperative, what more is needed to fuse the solid South and the solid North into one solid nation? No misrepresentatives of a dead past who may for a time infest the houses of Congress can long delay the conclusion. All opposition to these great industrial forces must go down before them. Corn and cotton are now our rulers, not colonels or brigadiers.

WANTED—AN EXHIBITION.

As a means to this great end one thing is needed, and that is a great exhibition exclusively devoted to cotton. What is the secret of its kingship? May it not be found in the fact that cotton or cotton fabrics are almost a legal tender for all the other commodities that the world yields or needs? In one form or another cotton works more international exchanges than any other substance. Two colored laborers working on good land in Mississippi, Texas, or Arkansas, may easily make twenty bales of cotton in a year, or 10,000 pounds, and with the aid of their children will pick it. The labor of ginning, bailing, and moving to Lowell will not exceed the value of the work of one more hand; the work done in Lowell in one year by one operative will convert the 10,000 pounds of cotton into 8,000 pounds of coarse cloth with which 1,600 Chinese may be amply clothed for one year, or 3,200 East Indians may supply themselves with the lesser clothing needed by them in their tropical clime.

The joint labor of the two colored laborers on the cotton field, one man to tend the gin, the press, and to move the cotton to the mill, and one French Canadian spinner or weaver, who may have just migrated to New England from Canada, suffices to give 600 citizens of the United States all the cotton fabrics they can use in a year, or to clothe 1,600 Chinese or 3,200 East Indians for the same period.

AN ECONOMIC EQUATION.

This is the measure to be applied to the coarse or common fabrics used by the million. One field hand, one to tend the gin and press and to move the bale to the factory, and two factory operatives will produce the same supply of the finer fabric. The economic equation may be stated in the following form: One or two men in agriculture, one man in preparing and transporting, one or two women spinning and weaving, are equal to the production of cotton cloth to meet the need of 1,000 to 3,000 inhabitants of the various parts of the world. Yet this great force, this factor in commerce, almost as potent as gold and more so than silver, at the present day has had but the most meager attention, even in the great Centennial Exhibition of 1876. It needs now a place in which all new inventions may be concentrated. The air is full of new efforts, new devices, many of them crude and insufficient, are being presented. The farmer of the South is eager to learn the methods of the North. If the results of all these efforts could be concentrated and exhibited at one time and in one place a foundation would be laid for progress in the next decade to which that of the last would seem as nothing. Who will undertake this work? Let the Agricultural Department, the cotton exchanges, the Northern associations of manufacturers, and the Southern associations of planters and farmers reply.

THE SADDLE AGAINST THE BUGGY.

THE memory of man extendeth to the day when the boys on the farm were proud to ride a fine young horse to church or to see the girls. He took pride in the colts and taught them to move freely under the saddle, and above all, when the colt was broken he was taught to walk. Now, the boys must have a fine buggy and harness, and the colt must show his style and speed all the time. The boy is in too great a hurry to allow the colt to walk. The colt, buggy, and boy are soon a used-up set by fast driving. The whole business of buggy riding by farmers' boys is expensive, extravagant, and demoralizing. Not one farmer in ten can afford such a turnout for the lad. Many of them buy a buggy and let it stand in the sun and storm. They are too poor to have a house for vehicles. Some men cannot afford the luxury of a buggy. If we could return to the fashion of riding on horseback we would save millions to the farmers, and the boys and girls would develop better forms and have better health. Any lazy lout can ride in a buggy, but to be a graceful rider on horseback one must have some energy and get-up in his nature. There is life and health in riding on horseback. The whole system feels the invigorating effect of it. The rider and the horse catch the fire of sympathy and excitement in the run or fast paces, and every nerve and muscle of the body is brought into healthful invigorating play. The mania for trotting horses has been felt on every farm in the land. The country is full of road horses that some man or boy loves to pull the string on. They are usually poor saddlers, slow walkers, and rough. We need a reform. The place to begin is in breeding a class of horses of good size, style, and action, that can move freely in more than one gait. The English market is open for such horses. The well-knit horse of good style and action, suitable for a hunter or a carriage, will bring better prices than our average horse. The farmer will find it to his interest to raise a class of colts that the boys will like to ride. He can raise three or four fine saddle colts for what one buggy and harness will cost, and a fair saddle horse will bring more than the average roadster.—*Nashville American.*

ACTION OF ELECTROLYSIS UPON BENZOL.—The author (A. Renard) has obtained a secondary glycol, $C_6H_4(OH)_2$, which he names iso-benzo-glycol. It is soluble in water, alcohol, and ether; melts at 171°, and sublimes, with decomposition at 200°. Its solution is reduced by cupropotassic liquor.

A CATALOGUE, containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50, stitched in paper, or $3.50, bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
37 Park Row, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ENGINEERING AND MECHANICS.—Improved Horizontal Steam Engine. 1 figure.—Improved engine for the underground haulage of coal wagons. 3943
The Beaumont Compressed Air Engine.—Fig. 1. Locomotive for tramways.—Fig. 2. Trial of the experimental engine at Woolwich Arsenal. 3943
New Orleans and Texas Railroad. 3944
Cost of Working a Gas Engine Compared with the Same Work done by Steam Power. By F. T. LINTON, Leith Gas Works. 3944
Shaft Furnace for the Refining of Cast Iron. 2 figures.—Sections of shaft furnace used by M. Krupp. 3944
On the Varying Condition of Carbon in Steel and its Influence on Eggertz's Coloration Process. By J. SPEAR PARKER. 3945
General Arrangement of Engines and Boilers of the Steamship City of Rome. Full page illustration.—General arrangement of machinery in elevation and plan. 3946
Steam Dredging for Oysters. 3947
The Steamship City of Rome.—Detailed description of ship and machinery.—2 figures.—Transverse sections through engine room and through boiler. 3947

II. TECHNOLOGY AND CHEMISTRY.—The Bottle Business.—Statistics of the manufacture and cost of bottles, lamp chimneys, etc. 3951
Reciprocal Displacements of the Halogen Elements. 3951
Progress in Fire Extinguishment. 3952
Volumetric Determination of Lead. By W. DIEHL. 3952
Preparation of Gelatine Bromide. By M. BASCHIERI. 3952
Synthesis of Citric Acid. By E. GRIMAUX and P. ADAM. 3952
Differential Thermometer for Class Demonstration. 1 figure. 3953
Portable Oven. 1 figure. 3953
Enamel for Hollow Ware. 3953
Horseshoe Nail Making. 3953
On the Treatment of Faded Prints for Copying. 3953
The Reversed Action of Light in Solar Photography. By J. JANSSEN. 3953
Action of Electrolysis upon Benzole. 3953

III. GEOLOGY, ETC.—Ancient Remains in a Pennsylvania Cave. 3953
Inaugural Address of President Ramsay at the Swansea Meeting of the British Association on the Recurrence of Certain Phenomena in Geological Time.—Metamorphism.—Volcanoes.—Mountain Chains.—Salt and Salt Lakes.—Fresh Water Lakes and Estuaries.—Glacial Phenomena.—Conclusions. 3954
The New Volcano in Lake Ilopango, Republic of San Salvador. 1 figure. View of Volcano in Lake Ilopango. 3957

IV. NATURAL HISTORY, ETC.—Pacific Salmon. 3957
The Colorado Potato Beetle.—Method of destroying. 3957
Canary Birds.—How to care for them. 3957
The Cotton Crop and its Possibilities.—Reign of cotton.—New values for the crop.—New trade for the North.—An Exhibition wanted. 3958

V. MISCELLANEOUS.—Sir Joseph Whitworth.—The life and inventions of England's most distinguished mechanic.—The invention of machine tools.—The first "True Planes."—Planing machines.—Measuring machines.—Measuring one-millionth of an inch.—The Whitworth rifle.—Whitworth guns in Virginia.—Improvements in ordnance.—Steel cannon.—Compressed steel.—Promotion of technical education.—Whitworth scholarships. 3960
Auburn Prison. 3964
The Saddle Against the Buggy. 3965

VI. ARCHITECTURE, ETC.—Stairs.—Early origin, and proper construction. 3949
Artists' Homes. No. 6. Mr. J. C. Dollman's House, Chiswick. Full page illustration. Perspective, plans, and details. 3948

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co. are Solicitors of American and Foreign Patents, have had 35 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all Inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured, with hints for procuring advances on inventions. Address

MUNN & CO., 37 Park Row, New York.
Branch Office, cor. F and 7th Sts., Washington, D. C.